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Test Report AA 60-0054
18 July 1960

AD842207

WS 107A-1 FLIGHT TEST WORKING GROUP

FLIGHT TEST REPORT

ATLAS MISSILE 60D

2 JULY 1960

Log No. T 11851

Copy No. 64

AMR RANGE TEST NUMBER 803

CONVAIR TEST NUMBER P1-402-00-60

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WS 107A (ATLAS) CLASSIFICATION CHANGED TO:

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AUTHORIZED BY: AIR FORCE LETTER
SAN BERNARDINO AIR MATERIEL AREA (SBAMA)
DATED 17 NOVEMBER 1965

MT-60-16248

RECLASSIFIED BY: RJ Cook
DEPT. 190-1 DATE 12-12-65

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FOREWORD

This report has been prepared to present preliminary information relative to the flight of Atlas Missile No. 60D. The information presented is based on visual observation and data evaluation to the extent permitted by time limitations. It should be considered as preliminary only and the final reports on this flight referenced for further information. The technical content has been prepared and jointly agreed upon by members of the WS 107A-1 Flight Test Working Group.

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SUMMARY

Atlas Missile 60D was launched ~~from AMR Complex 11, at 9158 EST~~ on 2 July 1960. The primary mission for this flight was to evaluate missile performance with the all inertial guidance system furnishing all guidance functions. This objective was not fully satisfied and the flight test was not successful.

Due to several inadvertent pressurizations of the engine LO2 and fuel tanks for unknown reasons, the helium supply in the control bottle was depleted and sustainer and vernier engine thrust levels were subsequently not properly maintained.

Performance of the inertial guidance system computer was not satisfactory with approximately 500 feet per second of Z axis velocity being lost during booster operation. Operation of other components was satisfactory.

As a result of the low thrust, sustainer and vernier cutoff discretes were not generated. The vernier engines shut down when control bottle pressure became too low to hold the propellant valves open. Sustainer thrust went to almost zero when the bottle pressure became too low to maintain gas generator LO2 reference helium pressure. The sustainer valves were closed upon the receipt of an automatic sustainer cutoff signal generated by the Mod III impact predictor system.

The re-entry vehicle separation sequence was satisfactorily initiated by the autopilot programmer. Re-entry vehicle impact was approximately 40 nautical miles short of the target.

TABLE OF CONTENTS

FLIGHT TEST OBJECTIVES

The primary objective of this flight was to evaluate the performance of an Atlas Missile when the guidance, discrete commands, and pre-arm signal are performed by the all inertial guidance (AIG) system.

Detailed objectives are listed on the following pages along with comments relative to the degree of satisfaction.

OBJECTIVES	ORDER	YES	NO	PART	COMMENT
1 - First Order					
2 - Second Order					
3 - Third Order					
Weapon System Objectives					
1. Evaluate ARMA Inertial Guidance System compatibility with all associated missile subsystems.	1	X			
2. Evaluate ARMA Inertial Guidance System performance (pre-flight and flight enviroment).	1	X			
3. Evaluate ARMA Inertial Guidance System's platform (IMU) performance (accelerometers, gyros, and servos and pitch and roll steering commands).	1	X			
4. Determine ARMA Inertial Guidance System instrumentation and airborne and ground telemetry performance (analog and digital signal converters).	1	X			
5. Evaluate ARMA Inertial Guidance System's digital guidance computer performance (generation of discrete signals, yaw steering commands and the pre-arm signal).	1	X			Stored Z velocity was low from prior to booster cutoff.

	OBJECTIVES	ORDER	YES	NO	PART	COMMENT
6.	Determine ARMA GSE performance (Alignment-countdown set A-CS lot IIm, and associated equipment).	2	X			
7.	Obtain data on ARMA system accuracy.	2		X		
8.	Evaluate flight control system performance (missile stability and execution of roll programs, steering commands, and discrete signals).	1			X	It is impossible to determine if the flight control system was responsible for the start tanks re-pressurization during booster phase.
9.	Determine re-entry vehicle separation performance and internal environment.	3	X			
10.	Obtain data on blockhouse and launch control equipment performance.	2	X			
11.	Obtain data on missile systems and GSE systems to establish repeatibility of performance.	2	X			
12.	Determine Acoustica Propellant Utilization and propellant loading system performance.	2	X			
13.	Determine re-entry vehicle dynamic pressure distribution, vehicle loadings, and vehicle motions.	2	X			

OBJECTIVES	ORDER	YES	NO	PART	COMMENT
14. Determine re-entry vehicle heat shield performance with emphasis on shield variations.	2	X			
15. Evaluate re-entry vehicle arming and fusing system performance (acceleration to impact).	2	X			
16. Evaluate the missile system with regard to engine start and potential causes for combustion instability.	1	X			
Non-Weapon System Objectives					
1. Obtain data on Strobe Op.ical Beacon System performance.	2			X	Camera shutters were closed prior to system activation.
2. Obtain data on ARW-62 Range Safety Command system performauce.	3	X			

FLIGHT TRAJECTORY

This flight was planned for a range of 4306 nautical miles with impact in the broad ocean area 400 nautical miles north-east of Ascension Island. The booster phase of the flight trajectory appeared normal. As a result of the loss of control bottle pressure, sustainer engine performance dropped off. This drop in engine performance resulted in a large deviation from the anticipated trajectory during sustainer phase. Impact was approximately 40 nautical miles short of the target. Impact points, computed from radar data, were in fair agreement.

Figure I presents velocity components versus time plotted from preliminary IP instrumentation system data.

Figure II presents impact points as determined from Azusa and IP instrumentation systems.

A comparison of nominal flight performance parameters as taken from flight trajectory simulation case 54D-08A, and actual test values taken from Azusa and telemetry data at booster cutoff are presented below. Nominal values at sustainer and vernier cutoff times and measured values at significant times after booster cutoff are also presented.

NOTE: All times in this report are based on range zero time which occurred at 0158: 22 EST.

Item	Unit	Nominal	Measured
Liftoff Weight	lbs	259,808	------
Pitch Plane Azimuth	degs	98°37'	98°36'
BCO Velocity	ft/sec	11,410	11,344
BCO Altitude	ft	260,116	275,565
BCO Range	nm	59.5	55.8
BCO Time	sec	141.0	141.0

Sustainer and Vernier Engine Shutdown

(Sustainer Main Fuel and LO2 Valves remained open, Vernier Valves closed)

Item	Unit	Nominal	Measured
Velocity	ft/sec		19,332
Altitude	ft		1,028,565

Item	Unit	Nominal	Measured
Range	nm		369
Time	sec		278.5
Automatic Sustainer Engine Cutoff (Sustainer Main Valves Closed)			
Velocity	ft/sec		19,602
Altitude	ft		1,189,756
Range	nm		459
Time	sec		307.6

Nominal values at planned cutoff times were as follows:

Item	Unit	Nominal	Measured
Sustainer Cutoff			
Velocity	ft/sec	20,377	
Altitude	ft	796,897	
Range	nm	304	
Time	sec	247.0	
Vernier Cutoff			
Velocity	ft/sec	20,227	
Altitude	ft	878,277	
Range	nm	348	
Time	sec	260.2	
Impact Data			
Impact Range	nm	4306	4266
Impact Latitude (Geodetic)	deg S	1°23.11'	1°5.80'

Item	Unit	Nominal	Measured
Impact Longitude (Geodetic)	deg W	12°9.87'	12°46.25'

NOTE: Nominal times are corrected for the difference between range zero and 2 inch motion. Measured impact coordinates are taken from GE/BRC Instrumentation System. Measured cutoff times are taken from telemetry recordings of discrete generation. Altitude is height above launch horizontal. Velocity is speed relative to the earth's surface. Range is horizontal range from the launch pad with the exception of impact range which is measured along the earth's surface.

IMPACT POINT COMPARISON

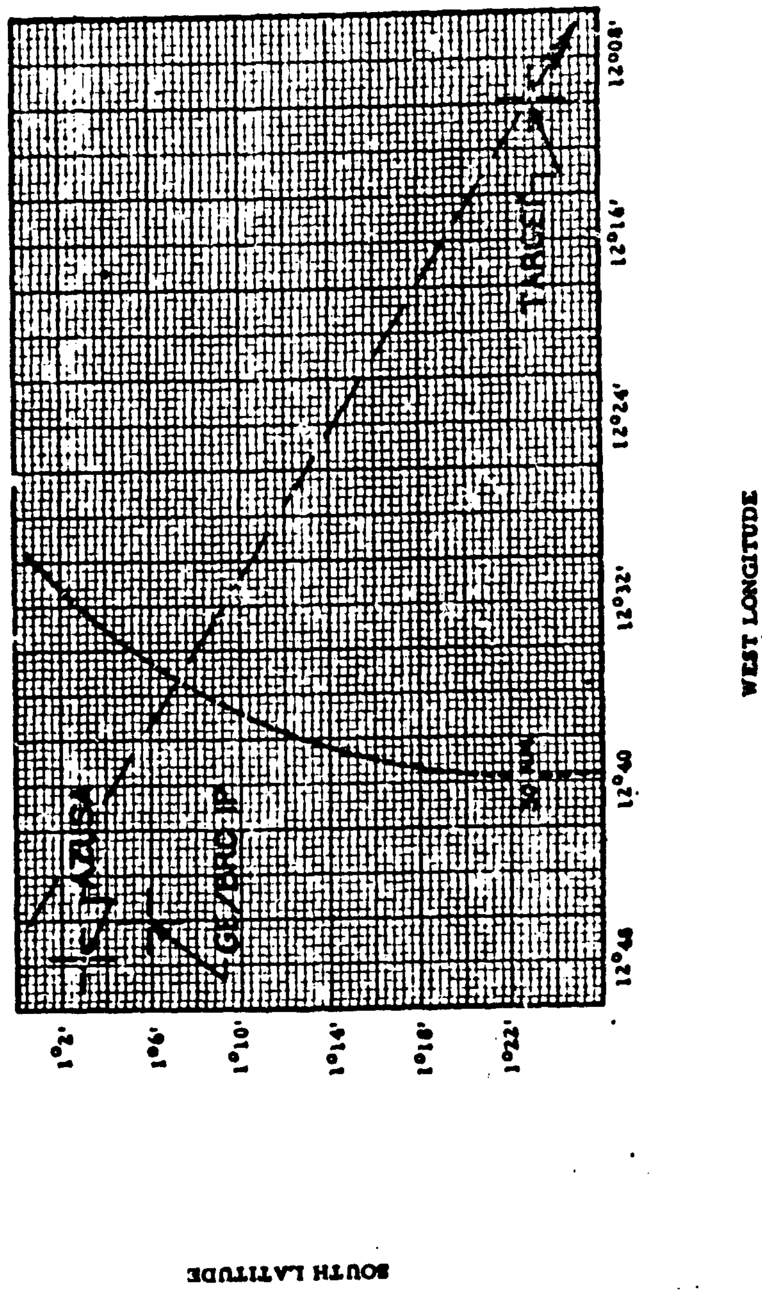


FIGURE 1

VELOCITY COMPONENTS
FROM PRELIMINARY I.P. INSTRUMENTATION SYSTEM

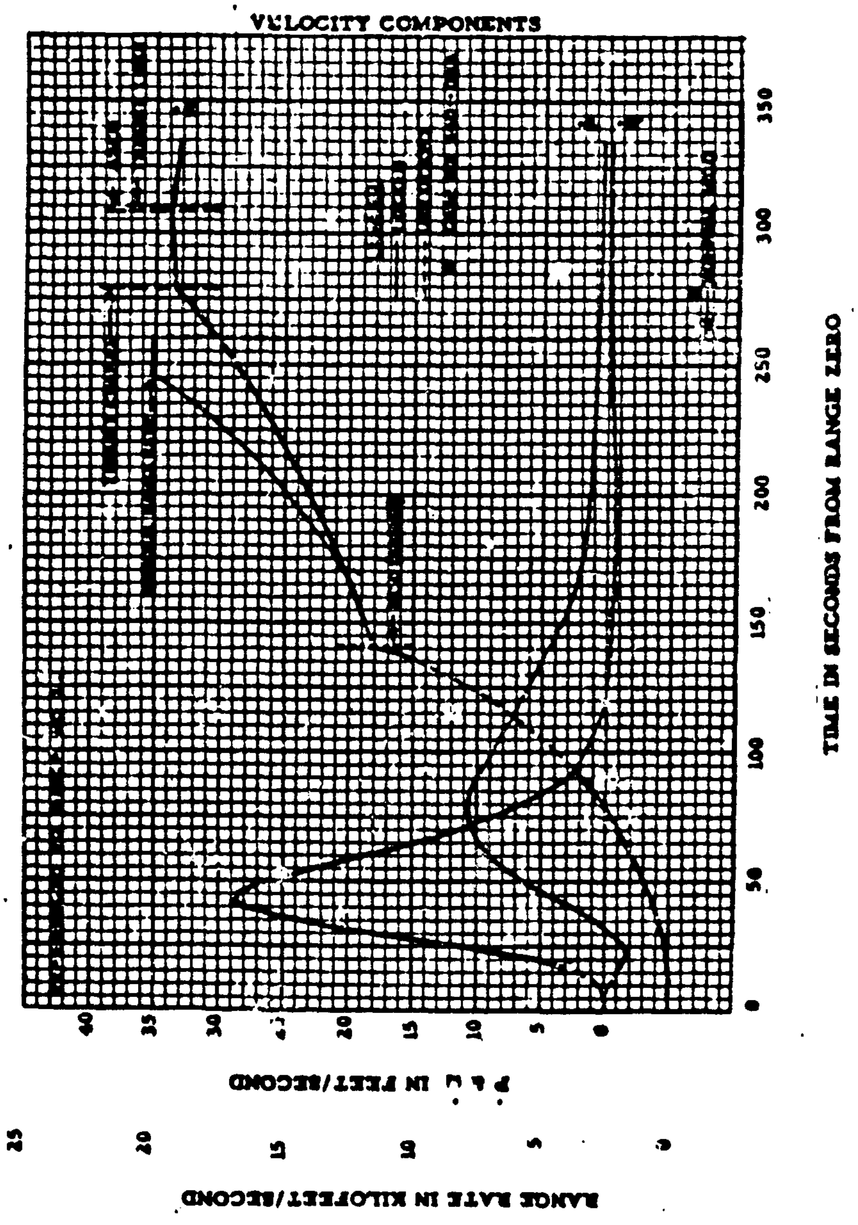


FIGURE II.

SYSTEM PERFORMANCE

AIRFRAME

Structural integrity of the airframe was maintained throughout powered flight and well beyond re-entry vehicle separation. Thurst section measurements indicated a temperature rise and illumination in the thrust section between 78 and 96 seconds.

Booster staging and separation of the Mark 3 Mod 1B Re-entry Vehicle appeared to be satisfactory as indicated by autopilot rate gyro data, M 26 D, Jettison Section Separation, and S 248 X, Release Payload Signal.

A 622 1, Thrust Section Light Detector in Quad 4, indicated illumination from 78 seconds to 96 seconds, reaching a maximum of 46 percent IBW by 80 seconds. All thrust section temperature measurements indicated temperature rises beginning at 78 seconds with A 746 T, Ambient at Vernier Hydraulic Flask, indicating a maximum temperature of 320°F at 103 seconds. The temperatures began to decrease slowly at approximately 96 seconds with the exception of A 746 T, Ambient at Vernier Hydraulic Flask, which started to decrease at approximately 104 seconds. Although the temperatures decreased, they remained generally above normal. The temperature rise indicated by the data had the same characteristics, although lower in magnitude, as the rise noted on Missile 42D, the first AIG missile, with the exception of A 747 T, Fuel Staging Valve shielded. During the Missile 60D flight this temperature reached a maximum of 301°F, however, during the Missile 42D flight the temperature only reached 141°F.

It should be noted that Missile 60D did not use the new booster boot cable clamps which are designed to provide more positive tightening of the boost around the booster thrust chamber and prevent possible recirculation of exhaust gases into the thrust section. Missile 54D used the new clamp and did not indicate an abnormal temperature increase.

Thrust section temperature maximums and corresponding times were as follows:

		Max Temp (dgf)	Times (secs)
A 743 T	Ambient @ S Inst Panel	82	108
A 745 T	Ambient @ S Fuel Pump	385*	94
A 746 T	Ambient @ V/D Flask	320	103
A 747 T	Fuel Stg Vlv Shielded	301	89

		Max Temp (dgf)	Times (secs)
P 14 T	Eng Comp Ambient	192	98
P 671 T	Th Sec Amb Quad IV	237	86

* Temperature not reading normally: The total resistance apparently shifted making the temperature reading too high.

PROPULSION SYSTEM

Propulsion System performance was adversely affected as a result of erratic pressurization and venting of the engine start tanks, which caused depletion of the controls helium supply early in flight. The cause of these inadvertent pressurization cycles has not yet been determined. The nature of the pressurizing and venting of the tanks indicates that they were caused by spurious electrical signals, as opposed to a mechanical malfunction. The tank pressures were the only associated parameters instrumented during this flight. No associated electrical functions were instrumented. Booster engine performance was affected as indicated by reduced performance levels of the booster pump speeds and chamber pressures during the pressurization periods. Sustainer engine performance was normal through approximately 128 seconds of flight. After this time the sustainer gas generator LO2 reference pressure regulator was unable to maintain its preset level. This led to the deterioration of gas generator output and consequently engine performance. Vernier engine performance followed, generally, the decreasing trend of the sustainer engine performance.

Telemetry data indicate that the engine start tanks were pressurized at 16 seconds and vented at 34 seconds, pressurized at 98 seconds and vented at 123 seconds, and pressurized at 128 seconds and vented at 174 seconds. Normal repressurization time, as controlled by the autopilot programmer, is 64 seconds after booster cut-off and repressurization was noted at this time (205 seconds). Booster engine performance was affected only during the pressurization periods. This was indicated by reduced performance levels of the booster pump speeds and thrust chamber pressures, evidently caused by the booster gas generator reverting to tank-fed operation on the fuel side during these periods.

Sustainer engine performance was normal through approximately 128 seconds. At that time controls bottle helium supply pressure reached the sustainer LO2 reference pressure regulator pre-set output level.

As a result of the excessive demand on the control bottle helium supply the helium pressure decreased, which in turn caused further drops in the sustainer LO2 reference pressure regulator. These regulator drops affected sustainer engine performance to a degree that at 266 seconds sustainer chamber pressure had decayed to 420 psia. At this time the start tanks vented apparently as the result of control pressure falling below that required to maintain the vent and relief valve in the tanks pressurized condition. This last vent dropped the controls bottle helium supply and sustainer LO2 regulator reference pressure to approximately 100 psia. Sustainer LO2 regulator reference pressure then decayed very slowly to approximately 80 psia by 278 seconds. Due to low pneumatic pressure the pneumatically operated vernier propellant valve closed, however, the hydraulically

operated sustainer propellant valves remained open for another 30 seconds. Sustainer cutoff was effected by the automatic sustainer cutoff signal at 307.68 seconds.

The engine start sequence was normal and all valve and timer operating times were within specifications. This was the first booster engine dry start for an AIG Missile since the destruction of Missile 48D. Release of the missile was delayed an additional 4.58 seconds by means of a timer. The rough combustion cutoff (RCC) systems were active during this additional time.

A total of nine Wiggins' quick disconnects were removed and replaced by solid plugs as follows: two in the B1 high pressure fuel ducting, three in the B2 high pressure fuel ducting, one in the booster turbopump low pressure ducting, one in each of the vernier orifice blocks, and one in the SGG fuel inlet line.

Oscillographic binary count data indicated the presence of a single count (approximately 3.5 milliseconds) on the B1 backup binary counter at the peak of the transient thrust buildup at engine start. B1 primary counter did not show count at that time, but did accumulate approximately 5 milliseconds of random count between -5 and zero seconds. RCC accelerometer data recorded on the FM landline system indicated low magnitude high frequency components superimposed on a low frequency acceleration for both booster chambers at the time the binary count was recorded on the B1 backup counter. Acceleration levels on all 5 RCC systems during mainstage appeared to be between 8 and 14 G's RMS which did not support the random count noted on the B1 primary counter.

Accelerometers mounted on the booster LO2 high pressure lines yielded questionable data due to instrumentation problems. The booster fuel high pressure lines indicated accelerations during mainstage between 15 and 25 G's RMS. Booster LO2 low pressure duct vibration was between 10 and 20 G's RMS during mainstage and booster fuel low pressure duct vibration was between 15 and 25 G's RMS during the same period.

Booster chamber pressures as recorded on FM data were considered qualitative only. Using the calibrations supplied, B1 and B2 pressures were 575 and 485 psia respectively. It is believed that transducers were reversed or serial numbers recorded in reverse as pressures were 540 and 525 psia respectively when the calibrations were switched.

Missile axial thrust levels during flight are presented as follows:

Engine	Units	L/L At Liftoff	After Liftoff	Prior To BCO
Vernier No. 1	lbs	---	854	844
Vernier No. 2	lbs	---	812	814
Booster No. 1	lbs	*	153,1[illegible]0	175,850
Booster No. 2	lbs	*	155,150	177,750

Engine	Units	L/L At Liftoff	After Liftoff	Prior To BCO
Sustainer	lbs	53,900	53,900	70,200

* Chamber pressure calibrations questionable equations used for computing thrusts were:

Verniers $F = (1.543 - \frac{P_o}{P_c} \epsilon) \quad P_c \, A_t \, \text{Cos } \theta$

Sustainer $F = (1.749 - \frac{P_o}{P_c} \epsilon) \quad P_c \, A_t$

Boosters $F = (1.586 - \frac{P_o}{P_c} \epsilon) \quad P_c \, A_t$

Where P_o = Ambient Pressure
P_c = Combustion Chamber Pressure
ϵ = Expansion Ration (Verniers = 5, Sustainer = 25, Boosters = 8)
A_t = Throat Area (Vernier = 2.10 in^2, Sustainer = 66,92, Booster No. 1 = 205.32 in^2, Booster No. 2 = 205.29 in^2)
θ = Angle of Verniers from Missile Longitudinal Axis in Pitch Plane.

TIMERS AND VALVE OPERATING TIMES

(all times in seconds)

	Sequence		Test Value	Specifications
1.	BGG valve opening control signal until valve reaches full open		0.52	0.330 to 0.590
2.	Main LO2 valve opeing control signal until valve reaches full open	B1	0.34	0.330 to 0.470
		B2	0.35	0.340 to 0.480
3.	Main fuel valve opening control signal until valve reaches full open	B1	0.12	0.090 to 0.170
		B2	0.12	0.090 to 0.190
4.	S HS valve opening control signal until valve reaches full open		0.64	0.480 to 0.780
5.	S PU valve opening control signal until valve reaches full open		0.63	0.480 to 0.770
6.	SGG valve opening control signal until valve reaches full open		0.42	0.340 to 0.490
7.	V Engine valve opening control signal until valve reaches full open	V1	0.55	1.500 maximum
		V2	0.46	1.500 maximum
8.	Ignition Stage Limiter opening control signal		2.39	2.16 to 2.64
9.	Holddown Timer		4.58	4.40 to 4.90

Measure-ment No.	Description	Units	Steady State Nominal Value	L/L At Liftoff	After Liftoff	Prior To BCO	Prior To Engine Shutdown
Engine Propellant Tank Pressures							
F 1288 P	ISS Pneu Reg Out	psia	615	637	669	575	93
P 27 P	Engine Fuel Tank Press	psia	610	---	142	566	111
P 30 P	Engine LO2 Tank Press	psia	610	---	20	575	35
Verniers							
P 28 P	V1 Thrust Chamber Press	psia	355	---	353	301	201
P 29 P	V2 Thrust Chamber Press	psia	355	---	338	290	195
Boosters							
F 1125 P	B Ctl Pneu Reg Out	psia	765	768	776	576	---
P 1026 P	B LO2 Reg Ref Press	psia	582	589	590	560	---
P 1100 P	BGG Chamber Press	psia	441	460	459	480	---
P 1017 T	B2 Turbine Inlet Temp	dgf	1200	1200	---	---	---
P 1001 P	B1 LO2 Pump Inlet	psia	---	77	---	---	---
P 1003 P	B2 LO2 Pump Inlet	psia	---	67	---	---	---
P 1002 P	B1 Fuel Pump Inlet	psia	73	76	---	---	---
P 1004 P	B2 Fuel Pump Inlet	psia	73	74	---	---	---
P [illegible]	B1 Turbopump Speed	rpm	6169	---	6013	6138	---

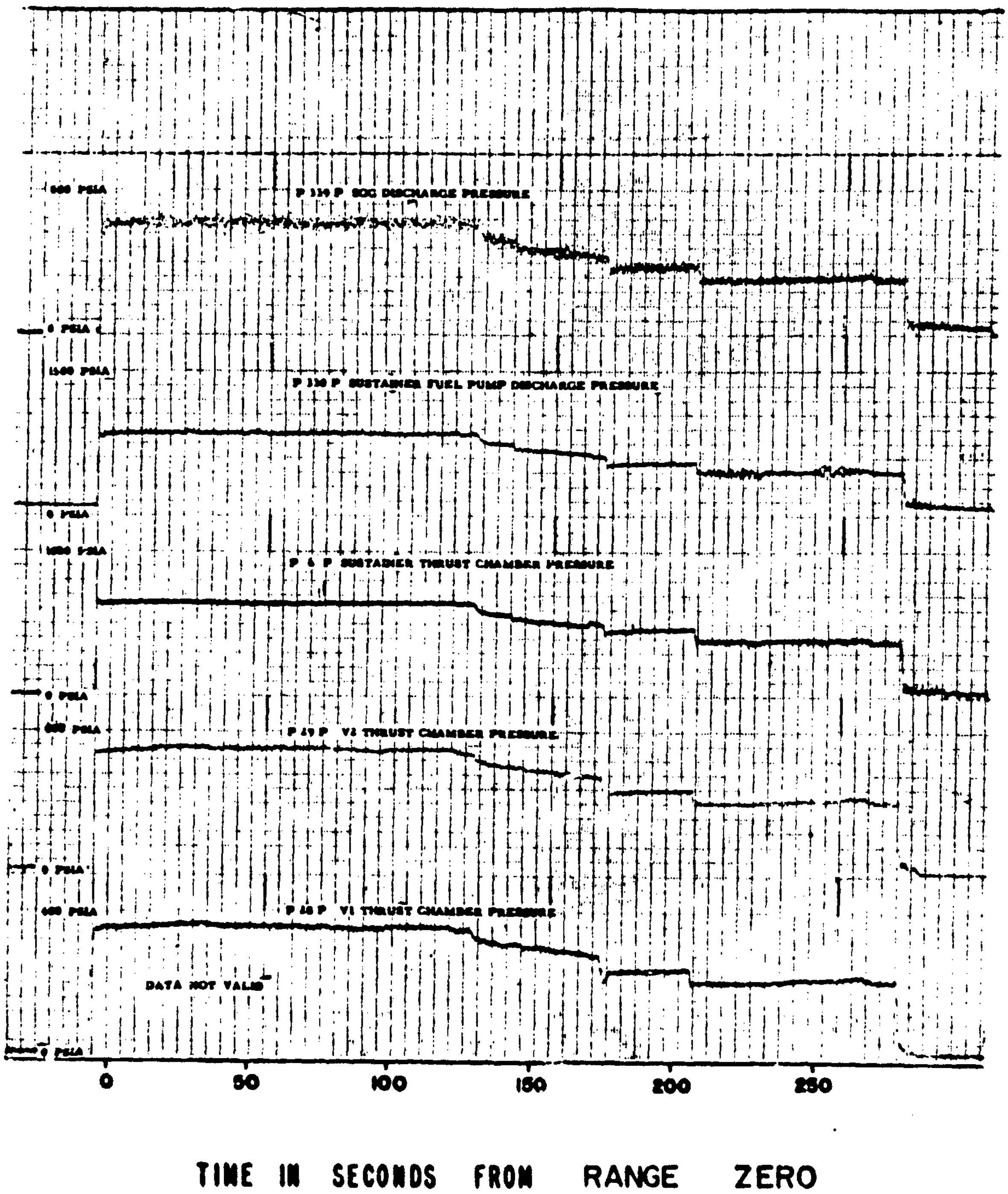
Measurement No.	Description	Units	Steady State Nominal Value	L/L At Liftoff	After Liftoff	Prior To BCO	Prior Engine Shutdown
P 83 B	B2 Turbopump Speed	rpm	6189	---	6013	6138	---
P 1039 P	B1 Fuel Pump Outlet	rpm	788	724	---	---	---
P 1038 P	B2 Fuel Pump Outlet	psia	820	724	---	---	---
P 1487 P	B1 Ign Fuel Injection	psia	---	615	---	---	---
P 1488 P	B2 Ign Fuel Injection	psia	---	6.75	---	---	---
P 1093 P	B1 Fuel Inj Manifold	psia	658	*	---	---	---
P 1094 P	B2 Fuel Inj Manifold	psia	658	685	---	---	---
P 1091 P	B1 LO2 Inj Manifold	psia	649	605	---	---	---
P 1092 P	B2 LO2 Inj Manifold	psia	649	625	---	---	---
P 1060 P	B1 Thrust Chamber Press	psia	544	---	546	540	---
P 1059 P	B2 Thrust Chamber Press	psia	544	---	552	546	---
Sustainer							
P 1344 P	S LO2 Reg Ref Press	psia	786	778	790	565	80
P 339 P	SGG Discharge Press	psia	589	---	600	504	296
P 530 T	S LO2 Pump Inlet Temp	dgf	---	---	-293	-287	-289
P 56 P	S LO2 Pump Inlet Press	psia	53	---	65	115	54
P 1326 T	S Turbine Inlet	dgf	1100	1112	---	---	---

Measure-ment No.	Description	Units	Steady State Nominal Value	L/L At Liftoff	After Liftoff	Prior To BCO	Prior To Engine Shutdown
P 349 B	S Turbopump Speed	rpm	9970	---	9990	---	---
P 330 P	S Fuel Pump Discharge	psia	974	---	885	728	450
P 830 D	S Main Fuel Valve Pos	deg	31.8	---	31	50	Full Open
P 529 D	S Main LO2 Valve Pos	deg	---	---	36	27.5	Full Open
P 351 P	S LO2 Inj Manifold	psia	814	---	800	690	470
P 1006 P	S Thrust Chamber Press	psia	693	685	675	600	410
Miscellaneous							
P 1021 T	LO2 At Breakaway Valve	dgf	-294	-292	---	---	---
P 671 T	Thrust Sect Amb Quad	dgf	---	---	60	163	155
P 1673 T	B1 Ign Fuel Valve Amb	dgf	---	39	---	---	---
P 1674 T	B2 Ign Fuel Valve Amb	dgf	---	65	---	---	---
P 1675 T	Eng Ctl Pneu Man	dgf	---	68	---	---	---
P 14 T	Eng Compartment Amb	dgf	---	---	43	120	86

* Instrumentation Malfunction

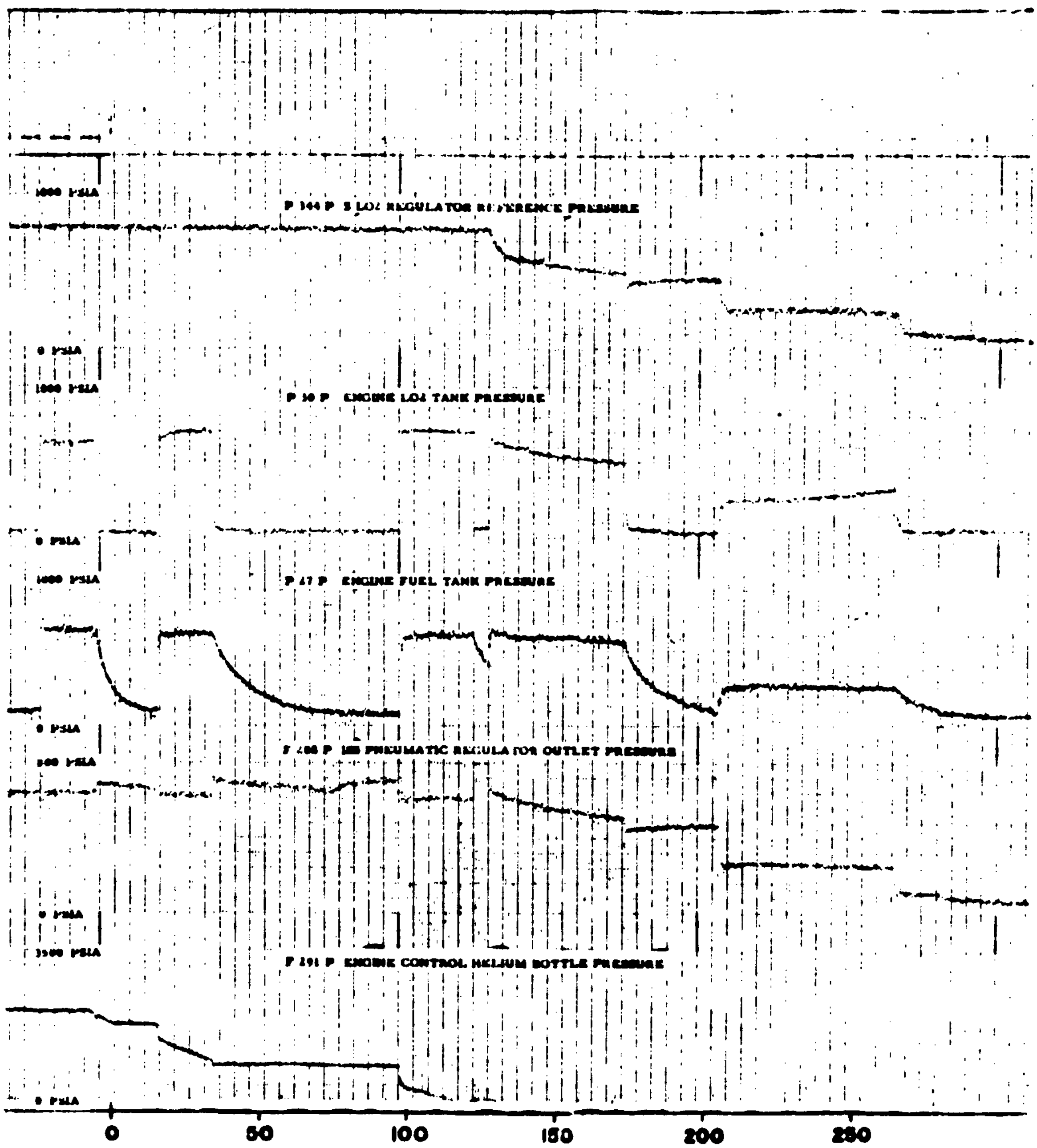
** Questionable Calibrations

PROPULSION SYSTEM DECOMMUTATED DATA



GRAPHIC NOT REPRODUCIBLE

PROPULSION SYSTEM AND PNEUMATIC SYSTEM DECOMMUTATED DATA



TIME IN SECONDS FROM RANGE ZERO

GRAPHIC NOT REPRODUCIBLE

PNEUMATIC SYSTEM

Re-pressurization of the engine start tanks occurred three times during the booster phase of flight causing depletion of engine control helium pressure early in flight. The nature of the pressurizing and venting indicates that they were caused by spurious electrical signals rather than a mechanical malfunction. Propellant tank pressures were satisfactorily maintained throughout flight and all tanks and bottle pressures were within specifications at liftoff.

Tank Pressurization System

Performance of the Hadley "D" Series LO2 and fuel pressure regulators was satisfactory. The initial LO2 tank cycling pressures at engine start were between 39.1 psia and 40.3 psia at 1 cps and the initial fuel tank cycling pressures were between 63.4 and 74.8 psia at 2 cps. Both LO2 and fuel tank pressures were satisfactorily maintained until well after re-entry vehicle separation.

Booster tank bottle pressure decayed from 3145 psia to 2810 psia during the ground run period and was satisfactorily maintained up to booster separation.

Engine Control Pressurization System

During the inadvertent repressurizations and venting of the start tanks, pressure lock-ups above the normal setting were noted in the ISS pneumatic regulator output pressure. After the second repressurization, lockup pressure decayed slowly back to the normal setting and then increased again before the third repressurization, for no apparent reason.

Both the ISS regulator and the booster controls regulator functioned normally until the decreasing control helium bottle pressure reached the regulator output levels. Starvation of these regulators began during the third vernier tanks repressurization and outputs continued to drop throughout the remainder of the flight until controls bottle pressure reached zero.

Telemetered engine control helium bottle pressure indicated approximately 1700 psi at liftoff and zero psi at 130 seconds. This was not reflected in other related data and was considered invalid and due to an instrumentation zero shift.

Values taken from landline and telemetry data at the times specified are presented on the following page.

Measure-ment No.	Description	Units	L/L At Liftoff	After Liftoff	Prior To BCO	Prior To Shutdown
F 1001 P	LO2 Tank Helium	psia	40.6	39.5	24.9	23.1
F 1003 P	Fuel Tank Helium	psia	73.3	75.8	59.8	53.9
F 1246 P	B Tank Helium Btl Hi	psia	2810	2618	619	----
F 1291 P	S Ctl Helium Btl	psia	2867	1768*	0*	0*
F 1304 P	Separation Btl Disch	psia	----	3220	3027	----
F 1125 P	B Ctl Pneu Reg Out	psia	768	776	576	----
F 1288 P	ISS Pneu Reg Out	psia	637	669	573	94
F 1194 P	Facility GN2 Supply	psia	1558	----	----	----

* Invalid data apparently due to instrumentation zero shift.

HYDRAULIC SYSTEMS

Performance of the hydraulic systems was satisfactory. The booster hydraulic system maintained an airborne system pressure of 3060 psia until booster cut-off. The sustainer hydraulic system maintained an airborne pressure of 3050 psia until sustainer cutoff.

The vernier solo hydraulic accumulator system operated properly after vernier engine shutdown which occurred at approximately 278 seconds. Pressure was available for 20 seconds after vernier engine cutoff. The accumulator bottomed out when the pressure reached 600 psia. Gas pre-charge pressure was 1000 psia.

MISSILE ELECTRICAL SYSTEM

Performance of the Missile Electrical System was satisfactory. Telemetered data indicated that satisfactory a-c and d-c electrical power were supplied until after re-entry vehicle separation. System parameters remained within specifications at all times.

The changeover from complex external power to missile internal power was accomplished without incident.

Missile main battery and inverter phase A voltage remained between 27.4 and 28.0 vdc and 113.42 and 113.72 vac, respectively, over the time interval from engine start to re-entry vehicle separation. Inverter frequency remained between 398.80 and 400.6 cps during this interval. Minor inverter frequency transients occurred at engine start, booster engine cutoff, sustainer and vernier engine cutoff, re-entry vehicle separation and retro-rocket firing.

RANGE SAFETY COMMAND SYSTEM

Performance of the Range Safety Command System was satisfactory. Automatic and manual fuel cutoff command signals were transmitted by AMR and were properly decoded by the airborne system during the flight. Final termination of sustainer engine thrust was effected by the automatic sustainer cutoff signal. Telemetered r-f input/agc data indicated that received signal strength was adequate to maintain proper system operation from launch until past re-entry vehicle separation.

The automatic sustainer fuel cutoff signal, generated by the A-1 computer at GMCF No. 1 and transmitted by AMR as a backup sustainer cutoff signal, was decoded at 307.652 seconds. The manual fuel cutoff signal, which served as a backup re-entry separation signal, was planned for 300 seconds. Since sustainer and vernier engine cutoffs did not occur at the expected times, it was requested that the transmission of the signal be delayed until 345 seconds. The manual fuel cutoff signal was decoded at 345.401 seconds.

AZUSA SYSTEM

Performance of the Azusa System was satisfactory. Realtime impact prediction plots were obtained during powered flight and trajectory information was obtained until 350 seconds. It was reported that cyclic track was maintained until 870 seconds.

Solid r-f lock was acquired at 30 seconds. All ambiguities in the cosine channels were resolved to fine by 47 seconds and no further resolutions were required prior to 350 seconds. At this time, a momentary dropout of signal at the AMR ground station necessitated the re-resolution of ambiguities. Ambiguities in the cosine channels were re-resolved by 390 seconds; however, ambiguites in the range channel could not be re-resolved.

During the countdown AMR reported a "GO" transponder. Received signal strength at the ground station was -115 DBW at 0115 EST. Recovery, modulation, and coherency were satisfactory and the 95 cycle sweep was present.

Telemetered data indicated that klystron power output was not within specification during the flight. The data level was 12 percent IBW whereas 25 to 100 percent IBW indicates proper operation. Since the klystron power output measurement is only a qualitative indication and the AMR ground station reported a normal received signal level throughout the flight, transponder operation was considered satisfactory. The indication of low kylstron power output was also observed during all previous tests on Missile 60D. Similar low klystron power output indications have been observed during the majority of the tests on D/AIG Missiles which use the type B-1A transponder.

Telemetered klystron beam voltage, transponder can gas temperature, and r-f input/agc data were satisfactory throughout the flight.

The Azusa Mark II site tracked passively during this flight.

OPTICAL BEACON SYSTEM

No position data were acquired although ballistic camera plates were obtained from all five camera sites. Telemetered data indicated satisfactory airborne system operation from manual fuel cutoff to well beyond re-entry vehicle separation.

Position data were not obtained since system activation was late and the ballistic camera shutters had been closed prior to activation. The guidance system cut-off discrete, which normally activates the system, was not generated and the system was activated approximately 100 seconds later than planned when the manual fuel cutoff (MFCO) signal was sent. This signal was sent at about 345 seconds, whereas the camera shutters were open only from 226 to 326 seconds.

Telemetered data indicated proper activation of the beacon system at 345.97 seconds by the MFCO signal. Normal system operation occurred for 40 seconds. After this time the flash rate gradually doubled and then became intermittent. Just prior to loss of data the flash rate became regular again, however, it was still at double the normal rate. At loss of data the pulse rate was back to the normal sequence of 2 pulses per second.

FLIGHT CONTROL SYSTEM

Performance of the Flight Control System was satisfactory. System data indicated satisfactory missile stability throughout powered flight.

Start tank repressurization occurred at approximately the programmed time of BCO + 64 seconds. In addition, the start tanks were repressurized and vented three times during the booster phase of flight, apparently as a result of undesired electrical signals instead of mechanical failure. The autopilot programmer is a possible source for these electrical signals since the programmer sends the signal for normal repressurization. However, investigation of the programmer circuitry indicates that it is unlikely that the programmer was at fault. All preflight checks of the flight programmer indicated satisfactory operation.

Thrust chamber displacements at engine start were within the applicable tolerance of ± 0.6 degrees. It was planned for the autopilot programmer to generate a roll program of 91.6 degrees to take the missile to an aziumth of 103.6 degrees true. Following the roll program the guidance system was to correct the roll to give the missile a true flight azimuth of 96.6 degrees. Flight control system data and radar plots indicated satisfactory roll and pitch programs.

The rate gyro data indicated an unusual high frequency vibration from 36 seconds to 52 seconds with the largest disturbance occurring in the roll plane. It is presently unknown what may have caused this vibration, however, various inertial guidance measurements also reflect this vibration. A review of Missile 54D data indicate a somewhat similar vibration at approximately the same time of flight.

Rate gyro data indicated normal propellant slosh during the booster phase of flight. Oscillations at booster cutoff and during staging were normal. Response to guidance steering commands was satisfactory.

The bending mode usually observed on "D" R and D Series Missiles during sustainer phase was not observed. This bending mode has not been present in any of the D-AIG flights.

Re-entry Vehicle separation occurred properly 215 seconds after booster cutoff as a function of the autopilot programmer.

All precountdown and countdown checks were satisfactory.

INERTIAL GUIDANCE SYSTEM

Performance of the Inertial Guidance System was satisfactory until shortly before staging, when a failure in the computer resulted in erroneous Z velocity readings. These Z velocity errors were equivalent to a miss of approximately 190 miles long. Sustainer Engine Cutoff, Vernier Engine Cutoff and prearm were not issued because of low missile acceleration. Sensing Platform Control, and digital signal converter performance was excellent. Instrumentation performance was satisfactory except for one vibration measurement.

Platform and Control

The performance of both the platform and control was satisfactory. For this test, the autopilot was deliberately set to provide about 5 degrees less than the required amount of roll. When the autopilot roll program was completed, the azimuth resolver indicated a reading of 5.5 degrees. The rate of correction was 2 deg/sec at the start of roll trim, gradually decreasing to 0.9 deg/sec at the end. At 19 seconds, the end of the roll trim program, the heading was 0 degrees, indicating that the roll correction was performed satisfactorily.

At "guidance enable" the pitch attitude was 5.5 degrees up. It required 13 seconds for the pitch steering to bring this to zero degrees. The pitch resolver output at 5.5 degrees was 1.37 volts rms. The guidance input torquing gain to the autopilot is 0.5 degrees/sec/volt. This gives an autopilot pitch gyro torquing rate of 0.69 degrees/sec. After pitch attitude reached zero degrees, it remained constant.

The servo errors were generally less than one minute and servo performance was satisfactory. Two corrections on the azimuth and roll servo channels occurred at 48 and 58 seconds during a period of high vibration. The corresponding resolvers indicated a 1.0 degree movement at the same time. This is discussed further in the paragraph on MGS vibrations.

The performance of the gyros was satisfactory. The gross drifts which were measured prior to flight were:

Azimuth	+1.15 °/hr	(Precount)
Pitch	+1.18 °/hr	(X-1 Day)
Roll	+0.19 °/hr	(X-1 Day)

These measurements were consistent with the previous history of the gyros. Gyro temperatures were satisfactory. Representative values are as follows.

Gyro	Buoyant Temp.	Prelaunch Temp.	Prelaunch Diff.	Vernier Cutoff Temp.	Vernier Cutoff Diff.
601 Pitch	66.7°C	67.8	+1.1	67.8	+1.1
602 Roll/Az	67.2°C	68.1	+0.9	68.1	+0.9

Accelerometer performance was satisfactory. All six string amplitudes remained at a constant level throughout the flight except during the period of apparent high vibration from 31 to 51 seconds. During this time the Zf1 and Zf2 string amplitudes varied considerably. The type of variation, including a DC level shift, indicates the fault was probably in the ASC and not in the accelerometer.

The accelerometer scale factors measured during precountdown and countdown were:

X 1.99816	$cps/ft/sec^2$
Y 1.99857	$cps/ft/sec^2$
Z 1.99739	$cps/ft/sec^2$

These values were consistent with the previous values obtained in component and systems tests at GCY and AMR. After the termination of thrust, accelerometer sum frequencies showed good agreement with previous values.

Binnacle temperature was in the control range of the proportional heaters throughout guidance.

Computer

The computer malfunctioned for a brief interval prior to staging. The cause of malfunction and the magnitude of error was determined from telemetry data.

The computer operation was normal in all other respects, and, knowing the error introduced before staging, the fine grain data reduction can provide overall accuracy evaluation in the terminal portion of the flight with little deterioration of data.

It was concluded that the readout circuitry from the sixth stage of the Z input reversible counter was inoperative during, and possibly before, the flight. The sixth counter stage is used only when the Z input accleration level reaches 4 "g's"

positive, or any amount negative. Neither of these input conditions occur in computer problems previously used in ground testing. A new series of computer test problems is being generated to uncover such malfunctions in the future.

Each failure of the sixth stage counter to read out a "ONE" caused a permanent loss of 8 feet per second in the Z main velocity register. This occurred 63 times in the interval from 148 seconds to 153 seconds (BECO) during the flight when the thrust acceleration reached 4 "g's". Throughout the remainder of the flight the computer Z velocity was in error by minus 504 feet per second.

Since the yaw steering signal is relatively insensitive to Z velocity, this function was normal. At the time of "guidance enable" the missile was to the right of its course. The computer commanded a small left turn and approximately 36 seconds later a small right turn. This maneuver reduced CEF essentially to zero and thereafter the missile remained on course. Under nominal flight conditions, the Z velocity error of -504 fps would have produced a crossrange miss of approximately 5 nautical miles right.

After VECO the thrust acceleration was zero and the Z input counter received an occasional negative count (normally). The sixth stage failure again caused an error of -8 feet per second. This occurred several times. This error indicates that the malfunction was permanent, not intermittent, since the counter failed at every opportunity.

Accuracy

An attempt was made to mathematically remove the effects of the malfunction described above and to estimate the system errors arising from other sourses. The remaining ARMA velocity errors just before burnout indicated a guidance miss of 2.1 nm short and 0.74 nm right. Even with uncertainty in these values, they indicate no malfunction or gross errors in other portions of the guidance system.

Alignment-Countdown Set

Performance of the Alignment-Countdown Set (A-CS) was satisfactory. Minor discrepancies noted during the prelaunch operations were:

1. During the precountdown, azimuth alignment was lost when mist formed on the platform window, probably due to moist air from the transfer room striking the cold glass. The condition was remedied by reversing the fan to draw air down the tube.

2. The optics fail-safe light indicated difficulty in maintaining alignment during the countdown. The telescope was adjusted in elevation to correct the difficulty. The telescope had been adjusted in elevation when missile "stretch" was removed, but further settling probably occurred when LO2 tanking was accomplished.

At launch, the A-CS recorder indicated the following alignment errors existed:

Tilt: Roll Pendulum: less than 0.5 second

Tilt: Pitch Pendulum: 0.5 second

The A-CS satisfactorily maintained the accelerometer zeros as shown in the table below:

Function	Nominal	Compensated Nominal	Actual	Error
X Offset	0.667	0.886907	0.886491	-0.000416
X	1.000	---	1.00186	+0.00186
Y	1.000	---	0.99867	-0.00133
Z	65.254	65.17044	65.17036	-0.00008

Missile Guidance Set voltages were within specified limits and were very stable throughout the guidance phase of flight except for control 115 volts phase B. This voltage was typically 113.10 volts but shifted to 111.1 volts eleven times during the guidance phase of flight for periods of 5 to 30 seconds.

A barely perceptible trend toward decreasing pressure was noted on the binnacle pressure channel. Launch "indicated pressure" was 16.65 psia. The 320 seconds indication was 16.50 psia.

Instrumentation Performance

All ASC channels functioned except binnacle X vibration (ASC Channel 20).

ASC temperature remained at 17°C (62.6°F) throughout powered flight.

DSC operation was normal and digital telemetry was good.

Missile Guidance Set Vibration History

The binnacle X vibration channel did not function on this flight. All other channels were active.

At liftoff, vibration levels were low in amplitude on all sensors. Peak values were about 3 g on computer Y and less than 1.5g on all other channels.

At staging, vibrations were below measureable amplitudes on all channels. Peak levels exceeding the saturation limits (over 10g) occurred on all 5 active channels during a 20 second period from 31 to 51 seconds.

Correlation with other instrumentation shows coincident autopilot rate oscillations of 46 cps with greatest amplitudes in yaw rates. Azimuth resolver and azimuth servo showed an abrupt disturbance during this time as did roll resolver and roll servo.

The accelerometer string amplitudes varied considerably during this period also. However, this disturbance is not seen on the double discriminated accelerometer strings, and the vibration data are questionable. After this time the levels dropped quickly to under 1g and only threshold levels were seen for the remainder of the guidance phase except for computer Y at SECO which showed roughly 2 g peak.

MOD III E INSTRUMENTATION BEACON SYSTEM

Performance of the Mod III E Instrumentation Beacon System was satisfactory. However, simultaneous disturbances in the rate and track subsystems occurred three times. Each disturbance was characterized by complete rate subsystem unlock, a small decrease in track subsystem received signal level, and a small track subsystem received frequency shift. The cause of these disturbances has not been determined and is under investigation.

The missile was tracked off the pad in the automatic monopulse mode and tracking was continuous until 345 seconds.

The A-1 computer performance was satisfactory throughout the flight. The automatic sustainer cutoff signal was generated by the computer at 307.575 seconds and was transmitted by AMR at 307.656 seconds. Final termination of sustainer engine thrust was effected by the ASCO signal.

Performance of individual subsystems was as follows:

Track Subsystem

Track Subsystem performance was satisfactory. The missile was tracked off the pad in the automatic monopulse mode and tracking was continuous until 345 seconds. The tracking characteristics for the first 49 seconds were typical, with maximum 2 mil, peak-to-peak, errors during the period when signal level variation normally occurs. Between 49 and 66 seconds, the elevation error signals exhibited a 3 cps variation of approximately 0.5 mil, peak-to-peak. The tracking errors and the received signal level smoothed out by 66 seconds and tracking was normal until 90 seconds when a simultaneous disturbance occurred in both rate and track subsystem received signals. An approximate 3 db decrease in AGC and a one megacycle shift in AFC occurred, and these levels persisted for 45 seconds. At 135 seconds both the rate and track subsystems recovered simultaneously.

Shortly after booster separation a similar rate and track subsystem disturbance occurred for 3.5 seconds. The changes in track and rate received signals were again coincident both at the beginning and the end of the disturbance.

From the recovery after booster separation until 258 seconds, tracking was smooth with error signals of 0.1 mil, peak-to-peak, with an averaged received signal level of -58 dbm. At 258 seconds the same type of disturbance occurred again for one second. The remainder of the tracking was normal. All track signal was lost at 345 seconds.

Rate Subsystem

The rate subsystem performance was considered satisfactory in that there was no indication of a ground station or airborne beacon malfunction. However, r-f disturbances were indicated during three periods of rate subsystem unlock.

The character of the received rate signal at all three rate receivers was nearly identical with the other D/AIG missiles for the first 90 seconds. At 90 seconds the rate subsystem unlocked simultaneously with a change in the track subsystem received signal. The unlock period was 45 seconds in duration at a projected signal level of -75 dbm. Telemetry data and ground station records both indicate continuous sweeping of the airborne rate beacon during this period. The rate subsystem regained lock at 135 seconds which lasted for 4 seconds. One second prior to booster cutoff, rate subsystem lock became intermittent with complete unlock for 4 seconds following booster separation. During the interval between 148 and 258 seconds, rate subsystem lock was solid with an averaged signal level of -87 dbm.

At 258 seconds, simultaneous with a change in track subsystem received signal characteristics, the rate subsystem was completely unlocked for one seconds. Rate lock was regained solidly after 2.5 seconds and solid lock was maintained until final loss of signal at 338 seconds.

A-1 Computer

The Mod III Computer (A-1) functioned properly throughout the flight and no equipment malfunctions were observed.

Computer data indicated that the missile velocity was far below normal during the latter portion of the sustainer phase. This condition caused the ASCO signal to be generated on other than true missile velocity. The computation of ASCO is a function of missile downrange IIP position and IIP velocity. In order to protect normal missile flights from possible incorrect computed data, certain equation quantities are limited (within the true physical limits of the missile). Downrange IIP velocity near sustainer cutoff is limited between 50 nm per second and 150 nm per second. During the flight of Missile 60D, the downrange IIP velocity near sustainer cutoff was approximately 11 nm per second. The computation of ASCO therefore, was based on true IIP position, but false IIP velocity (limited at minimum value of 50 nm per second). Subsequent calculations utilizing the ASCO equations and the true IIP velocity (approximately 11 nm per second) indicated that the sustainer engine should have been allowed to operate for approximately 2.5 seconds longer. This would have placed the IIP at ASCO close to the specified value (10 nm uprange from target).

IP data for this flight have been evaluated and are considered good. The following IP is based on nominal nose cone re-entry velocity and altitude.

	Mean Miss Distance	Standard Deviation	Deviation Of The Mean
Cross range	4.69 nm right	± 0.47 nm	± 0.13 nm
Down range	40.28 nm short	± 0.42 nm	± 0.11 nm

Discussion of Simultaneous Rate and Track Susbystem Disturbances

The 60D flight test exhibited characteristics uncommon to previous flight tests. The character of the disturbances noticed on this test have never been observed on Mod III radio guidance flight tests. The major airborne configuration difference is that a single antenna and waveguide is used for the airborne pulse and rate beacons on D/AIG Missiles. The following items are evident from the telemetered and ground station data.

1. The operation of both the airborne beacons and the ground system appeared normal except for the three periods in question.

2. All three intervals have the same characteristics present in both rate and track subsystems.

3. The first disturbance occurred at 90 seconds and was 45 seconds in duration.

4. The second disturbance was at 144.3 seconds, 0.5 seconds after booster separation, and was 4.2 seconds in duration.

5. The last disturbance occurred at 257.92 seconds and was 0.9 seconds in duration.

6. Each time the disturbance was observed the following characteristics were indicated:

   a. The rate beacon appeared to sweep continuously.

   b. The track received signal level decreased slightly, averaging 3 db decrease.

   c. The track subsystem receiver AFC shifted approximately 1 megacycle.

d. The rate beacon sweep, the track AGC decreased, and the receiver AFC shift all occurred simultaneously.

e. All three functions recovered at the same time.

f. With the exception of the period at booster separation, no other missile functions are correlatable to the track and rate subsystem disturbances.

g. Missile power appeared normal.

7. The rate and track susbystem received signals show an approximate 3 db decrease in signal after booster separation.

The altitude of the missile at the times of the distrubances was as follows:

Time	Altitude
90 to 135 Seconds	14.8 to 41.2 Nautical Miles
144 to 148 Seconds	49.7 to 53.3 Nautical Miles
258 to 259 Seconds	164.9 to 165.8 Nautical Miles

RE-ENTRY VEHICLE

A Mark 3 Mod 1B Re-entry Vehicle, Serial Number 223, was flown on Missile 60D. All systems were functioning properly at liftoff and appeared to function correctly for the entire flight. Separation was achieved and a roll rate of about 65 degrees per second was imparted to the vehicle.

Telemetry reception was received for the entire flight with the exception of a 27 second blackout period during re-entry. All powered flight and re-entry Arming and Fuzing events were received. The exact time that the arming and fuzing batteries were activated is not available because the telemetry reception was exceptionally noisy at the end of powered flight and the 70 kc SCO could not be decommutated.

The re-entry vehicle beacon was tracked from Stations 1, 3, 5, and 12. Two SOFAR detonations were reported.

The following is a list of events and the time of occurrance.

Pre-Arm Lockout	80.9 sec.
Separation	355.5 sec.
Separation Rate	5 inches per second

ACOUSTICA PROPELLANT UTILIZATION SYSTEM

Closed-loop performance of the Acoustica Propellant Utilization System was satisfactory. Performance was normal except for Station No. 2 operation. System control was maintained up until 169 seconds when both the Propellant Utilization (PU) valve and the Head Suppression (HS) valve went full open. This occurrence was due to sustainer fuel injection manifold pressure dropping sufficiently to allow the PU and HS auto-control valves to return to their static positions. The PU and HS valves stayed full open for the remainder of powered flight.

A discrepancy was noted at Station No. 2 in that no indication of LO2 sensor uncovering was observed. This allowed the error time counter to reset and position the PU valve at the nominal angle. This is believed to be a system failure since data at Stations No. 1 and 3 indicated normal operation and small error times.

Time shared oscillator data indicated the uncovering of Station No. 5 fuel sensor 5.6 seconds after uncovering of the respective LO2 sensor. This allowed the fuel monostable output to be locked out at this station since the error time counter had already reset to Station No. 6 Station No. 5 error time counter duration was 4.2 seconds

At Station No. 6, a fuel sensor uncovering was not observed. This would be expected considering that there was a large error at Station No. 5; the valves were at nominal from Station No. 5 operation until 169 seconds, were then full open until Station No. 6 operation, and there was a nominal error time counter duration at Station No. 6 of approximately 3.2 seconds.

PU valve movement was correct in direction to error time counter output during the time the valve was in auto-control.

PU valve position data indicated an excursion towards open from just after booster cutoff to Station No. 5 operation. Other related data (sensor triggerings, counter outputs, and PU valve position feedback) indicated no changes during this time. Similar data were also noted on flights of Missiles 54D and 27D at that time. There is no explanation for this occurrence at the present time.

Configuration in this test consisted of a 6 card computer, which delayed the signal from the time shared oscillator to the monostable multivibrator by approximately 2.5 seconds, and a schmitt trigger, which is designed to prevent monostable triggering with an oscillator output of less than 100 milliseconds. Operation appeared satisfactory.

Time shared oscillator output times, monostable multivibrator output times, delay times, error times, and PU valve angle data were as follow:

Station No.	Uncover Time	LO2 Monostable Output Time	Time Delay	Fuel Sensor Uncover Time	Fuel Monostable Output Time	Time Delay	Error Time	PU Valve Position. Feedback	PU Valve Angle
1	2.77	5.20	2.43	2.77	5.20	2.43	0	31.0	31.5
2	-----	-----	-----	44.61	47.02	2.41	-----	30.5	31.5
3	84.73	87.19	2.46	85.38	87.86	2.48	0.65	52.5	51.6
4	118.72	121.13	2.41	119.41	121.87	2.46	0.69	53.5	51.6
5*	141.38	143.78	2.40	147.04	-----	----	5.66	31.4	31.5
6	217.98	220.33	2.35	-----	-----	----		Full Open	Full Open

* PU valve went out of control at 168.96 seconds

Valve position data indicate the valve was correctly positioned at nominal prior to Station No. 1 operation.

NOTE: Accuracy of times quoted for sensor uncovering is plus zero minus 33 1/3 milliseconds. Accuracy of times quoted for the monostable operations is ± 50 milliseconds. Error times are the differences between the LO2 and fuel sensor uncoverings. All times are in seconds.

PROPELLANT LOADING

The missile was propellant tanked utilizing the Propellant Loading Control Monitor (PLCM) as the primary tanking system with the load cells and Propellant Loading Control Unit (PLCU) serving as monitoring systems.

Fuel was tanked during X-1 Day for the attempted flight and left in the missile for this test. Fuel was tanked to a level halfway between the PLCM 100 and 100.2 percent probes. LO2 was tanked during the countdown to a level 600 lbs. above the PLCM 100.2 percent probe.

Correlation among weight monitoring systems was satisfactory with the exception of the fuel flow totalizer which has been yielding invalid data during this and past tests.

	Units	Desired*	Load Cells	PLCM	PLCU
LO2 Weight at Ignition	lbs.	174,257	174,555	174,257	------
Fuel Weight at Ignition	lbs.	75,961	76,648	75.961	75961
Missile Wet Weight	lbs.	15,741	15,741	15,741	------
Ignition Weight	lbs.	265,959	265,944	265,959	------
Ground Run Consumption**	lbs.	9,793	9,793	9,793	------
Lift-Off Weight	lbs.	256,166	256,151	256,166	------

* Desired values are based on actual weights, actual densities and planned volumes.

** Based on actual run time and nominal flow rates.

Weather Data

	Fuel Tanking	Ignition
Barometric Pressure	30.070 In. of Hg.	30.040 In. of Hg
Ambient Temperature	80.6°F	78.2°F
Relative Humidity	85 Percent	91 Percent

	Fuel Tanking	Ignition
Wind-Velocity and Direction	7 Knots, North-Northeast	5 Knots, South-Southwest
Cloud Coverage	8/10	1/10

HOLDDOWN AND RELEASE SYSTEM

The Holddown and Release System operated satisfactorily in restraining the missile prior to release and in releasing the missile at liftoff. All data taken from oscillograph records were within specifications except for B2 residual pressure which was 133 psig over maximum specification. Residual pressure data were based upon zero pressures taken 5 seconds after the blowdown. This was necessary since holddown cylinder pressure data after liftoff were affected by engine blast and were erratic.

Event	Specification	Test Value
Release signal to 2550 psig	0.5 sec. max.	B2 = 0.360* B2 = 0.378*
Time difference between start of B1 and B2 cylinder pressure decay	0.010 sec. max.	0.002
Time intercept of tangent at 2550 psig	0.110 sec. min.	B1 = 0.134 B2 = 0.147
Residual pressure 0.5 seconds after 2550 psig	350 psig max.	B1 = 318 B2 = 483
Maximum differential cylinder pressure after 2550 psig	400 psid max.	165 psid

* Time between release signal and 2550 psig was based on release signal obtained from EA data as release signal on oscillograph failed to activate.

EXTERNAL INSTRUMENTATION

Data recording systems other than telemetry and Convair acquired landline instrumentation were satisfactory, as reported in item 1.0-10, preliminary estimate of data coverage. The following report was received.

Instrumentation	60D DTO Requirements	Test Results
Optical Coverage		
32 Engineering Sequential Cameras	4.1.5.1 and 4.1.5.2	Satisfactory with the exception of item 12.2-100 which obtained zero coverage due to clouds.
13 Metric Cameras	4.1.5.3 and 4.1.5.4	Satisfactory.
5 Ballistic Cameras	4.1.5.5	Satisfactory. Photographic plates were obtained from all five sites.
Electronic Coverage		
FPS-16 (XN-1 at PAFB)	5.4.1.1	Tracked from 25 seconds to 290 seconds.
FPS-16 (XN-2 at GBI)	5.4.1.1	Tracked from 82 seconds to 385 seconds.
FPS-16 (Station 12)	5.4.1.1	Tracked from 17[illegible] seconds to 1603 seconds.
Mod IV (X-Band)	5.4.1.2	Tracked from 20 seconds to 110 seconds.
Azusa	5.4.1.3	Tracked from 30 seconds to 350 seconds.

AIRFRAME INTERNAL INSTRUMENTATION SYSTEM

Operation of the Telemetry System was satisfactory, and RF signals were received at the Cape for approximately 16 minutes. There was a short dropout on RF No. 1 for approximately 2 seconds at 356 seconds (after nose cone separation).

There were two discrepancies noted in telemetry measurements:

1. A 745 T, Ambient at Sustainer Fuel Pump, did not perform normally. The total resistance apparently shifted making the temperature reading too high.

2. F 291 P, Sustainer Control Helium Bottle. This measurement indicated an erroneous reading approximately 1100 psia low, and the transducer apparently opened about 13 seconds before booster separation.

Missile 60D contained three Bendix Mod 7 FM telemeter packages operational at the following frequencies and with the following subcarriers and commutation capabilities:

RF No.	Frequency	Continuous Channels	Commutated Channels
1	227.7	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, E	11, 12, 13, A, C
2	229.7	2, 3, 4, 5, 6, 7, 8, 9, 10, 12, A, C	11, E
3	232.4	5, 8, 9, 13, A, C, E	

Basic telemetry channel assignment is given in Convair Report AZC [illegible]1-63. Included in that report are channel assignment, commutation information, frequency response, and make and model of transducer.

LANDLINE INSTRUMENTATION

The landline instrumentation system provided satisfactory information prior to missile liftoff, however, the measurements listed below were only partially satisfactory for the reasons stated.

Measurement No.	Description	Source	Comment
N 1344 T	Transfer Room Temp.	Brown	Timing pen failed to function.
P 1017 T	B2 Turbine Inlet	Brown	Timing pen failed to function.
P 1326 T	S Turbine Inlet Temp.	Brown	Timing pen failed to function.
P 1059 P	B2 Thrust Chamber	Osc	Questionable calibration. Due to calibration portion of oscillograph being heavily overexposed.
P 1060 P	B1 Thrust Chamber	Osc	Questionable calibration. Due to calibration portion of oscillograph being heavily overexposed.
P 1901 P	B Fuel Jacket Purge	Osc	Calibration invalid.
P 1020 T	B1 LO2 Pump Inlet	Osc	No calibration.
P 1054 T	B2 LO2 Pump Inlet	Osc	No calibration.
A 1801 O	B1 High Pressure LO2 Line	FM	Instrumentation malfunction.
P 1093 P	B1 Fuel Injection Manifold.	FM	Instrumentation malfunction.
A 1802 O	B2 High Pressure LO2 Line	FM	Instrumentation malfunction.

FILM REVIEW

A review of quick process engineering sequential films indicated all missile and launcher systems functioned properly from ingition to the limit of camera coverage.

Operation of both east and west launcher heads appeared normal and in general launcher operation was satisfactory. Tracking film indicated the missile roll program was smooth and proper in all respects and that missile performance was satisfactory until the missile disappeared into the clouds during booster phase.

A tabulation of film items reviewed is presented on the following page.

Item No.	Camera Pad	Size MM Color or B/W	Frames per sec	Fixed or Tracking	Field of View
1.2-6	11-2	16C	400	Fixed	Entire launcher and missile to above vernier. View of Quad III fuel fill and drain valve.
1.2-7	11-10	16C	400	Fixed	Entire launcher and missile to above vernier. View of Quad IV LO2 fill and drain valve.
1.2-8	Ramp	16C	400	Fixed	View of entire missile looking into Quads I and II.
1.2-10	D17R39	16C	48	Tracking	View of entire missile looking into Quads I and II.
1.2-29	East A-Frame	16C	400	Fixed	View of B2 high pressure propellant lines at bottom of clamshell doors.
1.2-30	West A-Frame	16C	400	Fixed	View of B1 high pressure propellant lines at bottom of clamshell doors.
1.2-31	North Launcher	16C	100	Fixed	Views upper portion of turbine exhaust duct.
1.2-32	East Launcher	16C	400	Fixed	Views booster and sustainer thrust chambers and thrust section area.
1.2-33	West Launcher	16C	400	Fixed	Views booster and sustainer thrust chambers and thrust section area.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The helium bottle supply was depleted by several inadvertent pressurization cycles of the engine LO2 and fuel tanks. Sustainer and vernier engine thrust levels decayed early resulting in abnormal flight performance.

2. Performance of the inertial guidance system computer was not satisfactory. An inoperative computer register caused the stored Z axis velocity to be low.

Recommendations

1. Investigate cause of inadvertent engine LO2 and fuel tank pressurization.

2. Amend checkout and test procedures to provide a more thorough check of the inertial guidance computer.

COUNTDOWN TIME VERSUS EVENTS

This test was scheduled for a 150 minute countdown and started as planned at 2030 EST on 5 July 1960. There were 3 holds and one recycle which totaled 178 minutes resulting in a total countdown time of 328 minutes. The holds and recycle were as follows:

1. At -45 minutes (2215 EST), for 6 minutes, to replace a noisy B2 RCC audio warning amplifier.

2. At -12 minutes (2254 EST), for 114 minutes, to replace the missile main battery. The remotely activated battery failed to activate at -15 minutes. The count was recycled to -70 minutes, a new battery was installed and activated, the count advanced to -45 minutes, and the count resumed.

3. At -30 minutes (0103 EST), for 25 minutes, to replace a ruptured disc in the LO2 topping line.

No further difficulties were encountered and the remainder of the countdown was performed as planned.

The following notations were made by an observer in the blockhouse:

EST	Countdown Time	Countdown Procedure	Event
2030	T-150	T-150	Countdown Started.
		T-150	GAP Test Preparation Started.
		T-150	Acoustics Test Equipment Warm-up.
2035	T-145	T-145	Readiness Callout By Flight Control. All Systems Ready For GAP Test.
2036	T-144	T-144	GAP Test Started.
2045	T-135		GAP Test Completed Satisfactorily.
2039	T-131	T-135	Range Safety Command Test Started.
2057	T-123		Range Safety Command Test Completed.
2058	T-122	T-125	Start Electrical Connection of Red

EST	Countdown Time	Countdown Procedure	Event
			Destruct Box.
2100	T-120		Retro-rocket Installation Completed.
2102	T-118		ARMA Completed Zero Z, Scale X (+1G Field) Accelerometer Checks.
	T-118	T-120	Started Scale X (-1G Field) Accelerometer Check.
	T-118		Red Destruct Boxes Installation Finished.
2109	T-111		Beacon Test Started.
2117	T-103	T-120	Removal AIGS Landlines.
2119	T-101	T-90	Normal Align-Scale Z Accelerometer Checks Started.
2121	T-99	T-100	Flight Control System Test Started.
2125	T-95	T-95	Service Tower Removal And Securing Started.
2131	T-89		Nose Cone C Band Beacon Test Started.
2134	T-86	T-75	Computer DSC Checks Started.
2136	T-84	T-85	Helium Pressure Storage Preparation Started.
2142	T-78		Helium Storage Preparation Finished.

EST	Countdown Time	Countdown Procedure	Event
2143	T-77		Computer DSC Test Completed.
2145	T-75		Reported B2 RCC Audio Warning Amplifier Noisy.
2151	T-69	T-70	Started Helium Storage.
2156	T-64	T-65	GAP Test Preparation Started.
	T-64	T-65	Started Landline Electrical Calibrations.
2159	T-61	T-62	GAP Test Started.
2200	T-60		Nose Cone Beacon and Telemetry Checks Completed.
2209	T-51		GAP Test Completed Satisfactorily.
	T-51	T-45	Insert Z(-1G) Bias Checks Started.
2211	T-49	T-45	Autopilot Roll Gyro Torquing Ramp Test Started.
2215	T-45H		Holding For Audio Warning Amplifier Replacement.
2218	T-45H	T-50	Landline Calibrations Completed.
2219	T-45H		Insert X Offset Checks Started.
2221	T-45		Countdown Resumed.
	T-45	T-45	LO2 Tanking Preparation Started.
2231	T-35	T-35	LO2 Tanking Started.
	T-35	T-35	Azusa Check Started.

EST	Countdown Time	Countdown Procedure	Event
2241	T-25		Stopped Pumps LA And LB - Pumps Cavitating Due To Low Storage Tank Pressure.
2243	T-23		Start Pumps LA And LB.
2245	T-21	T-22	Range Safety Command Final Test Started.
2246	T-20	T-20	Autopilot Final System Checks Started.
2248	T-18		Insert X Offset Checks Completed.
	T-18	T-20	Accelerometer Adjustment Check Started.
2252	T-14		Reported That The Missile Main Battery Did Not Activate At T-15.
	T-14		Stop LO2 Tanking - Secure.
2254	T-12H		Holding For Replacement Of Missile Main Battery.
2254	T-12H		Detanking LO2.
2255	T-70H		Recycled To -70 Minutes And Holding.
2319	T-70H		Detanking Completed.
2327	T-70H		Battery Activation Relay Worked.
2420	T-70H		New Battery Installed And Activated Upon Installation.

EST	Countdown Time	Countdown Procedure	Event
2440	T-70H		Refilled Helium Storage Bottles.
2448	T-45		Countdown Resumed At -45 Minutes.
2450	T-43	T-45	LO2 Tanking Preparation Started.
2459	T-34		Azusa Checks Finished.
	T-34	T-35	LO2 Tanking Started.
0100	T-33		Ruptured 2 Inch Disk In LO2 Topping Line.
0103	T-30H		Holding For LO2 Tanking.
0128	T-30		Countdown Resumed.
0136	T-22	T-22	Range Safety Command Final Checks Started.
0138	T-20	T-20	Accelerometer Adjustment Checks Started.
0139	T-19	T-20	Autopilot System Final Checks Started.
0140	T-18	T-20	Started Telemetry Final Warmup.
0144	T-14	T-14	Nose Cone Telemetry "ON".
0145	T-13		Azusa Checks Completed.
0147	T-11	T-12	Nose Cone Beacon "ON".
0148	T-10	T-10	Started Acoustics Sensor Response Checks.
0149	T-9		Range Safety Command Final Test Finished.

EST	Countdown Time	Countdown Procedure	Event
	T-9	T-20	Autopilot System Final Checks Completed.
0150	T-8		Activated Strobe Light Satisfactorily.
0151	T-7		Acoustica Sensor Response Checks Finished.
	T-7	T-7	Guidance Final Checks Started.
	T-7	T-7	RCC Inactive - Active Switch To "Active".
0152	T-6	T-7	Forecast Final Range Clearance.
0153	T-5:00	T-5:00	Counting.
	T-3:50	T-3:50	Status Check - All System Reported "GO".
	T-3:30	T-3:30	Telemetry To Internal.
0155	T-3:00	T-3:00	Timer Off - Ready Switch To "Ready".
	T-2:40	T-2:40	Nose Cone Switch To Internal.
	T-2:30	T-2:30	Turning Water Systems "ON".
	T-2:10	T-2:10	Securing LO2 Tanking.
0156	T-2:00	T-2:00	Starting Flight Pressurization.
	T-2:00	T-2:00	Commands To Internal.
	T-1:45	T-1:45	Arm Switch To "ARM".
	T-1:45	T-1:45	Engine Preparation Complete Light "ON".

EST	Countdown Time	Countdown Procedure	Event
	T-1:40	T-1:40	Missile To Internal Power.
	T-1:35	T-1:35	Nose Cone Report Switch To "Ready".
	T-1:30	T-1:30	Removing Arming Safety Pin.
	T-1:25	T-1:25	Commands To "ARM".
	T-1:15	T-1:15	Status Check - All Systems "GO".
0157	T-0:60	T-0:60	-60 Seconds And Counting.
		T-0:60	Missile Helium To Internal.
		T-0:60	Autopilot To "ARM".
	T-0:55	T-0:55	Water Full Flow.
		T-0:55	PSO Range Ready Switch "ON".
	T-0:40	T-0:40	Status Check - All Systems Reported "GO".
		T-0:40	All Pre-Start Panel Lights Are Correct.
		T-0:40	Ready Light "ON".
	T-0:25	T-0:25	Oil Evacuate.
		T-0:25	Evacuation Lights "ON".
		T-0:25	Nose Cone Umbilical Eject.
	T-0:18	T-0:18	All Recorders To "FAST".

EST	Countdown Time	Countdown Procedure	Event
		T-0:18	-18 Seconds And Counting.
		T-0:18	Engine Start.
0158:22			Range Zero.

MISSILE CONFIGURATION

The Atlas Missile consists of three basic sections: re-entry vehicle, body section, and propulsion system. There are no external aerodynamic control surfaces. The re-entry vehicle is releasable and carries instrumentation and ballast to simulate the operational re-entry vehicle. The body section of the missile consists primarily of a thin-walled, pressure stabilized, stainless steel tank, housing the missile propellants. Missile propulsion is provided by the Rocketdyne MA-2 rocket engine propulsion system. Missile stability is accomplished by a flight control system consisting of an autopilot and a hydraulic system to gimbal the thrust chambers.

The following is a resume of the major systems and components comprising Missile 60D. Additional details are included for systems being flight tested for the first time, as well as systems which have received significant modifications.

Airframe

Standard D Series AIG Configuration.

Re-entry Vehicle

GE Mark 3, Mod 1B.

Pneumatic System

Standard "D" Series pneumatic system with Hadley "D" tank pressurization regulators.

Hydraulic System

The hydraulic system is comprised of three independent hydraulic systems which provide pressure for the booster stage subsystems, the sustainer/vernier subsystem, and the vernier solo subsystem.

Electrical System

Remotely activated battery, rotary inverter, and magnetic amplifier regulator system.

Acoustica Propellant Utilization System

The Acoustica PU system utilized with D/AIG missiles differs from the version used with radio guided missiles in the following respects:

1. The 5 KC oscillator has been changed to a 400 cps oscillator which feeds the transducer driver and phase sensitive detector.

2. A six (6) card computer system replaces the five (5) card system used by Acoustica on radio-guided missiles. This additional card provides for the requirements of sensor-delay adjustments.

3. A Schmitt trigger was incorporated in the circuitry between the oscillator and the monostable multivibrator. Purpose of the trigger was to prevent spurious monostable triggering with an oscillator signal at less than 100 milliseconds.

Anti-Slosh Control

Eleven annular baffle rings were installed in the LO2 tank to reduce propellant "sloshing".

Propulsion System

Basic Rocketdyne MA-2 engine assembly.

The propulsion system utilized "dry" start.

Booster Staging System

Standard "D" Series configuration, which utilized a separate fiberglass bottle to supply pneumatic pressure to actuate the release fittings.

Flight Control

Flight Control for Missile 60D was provided by ARMA all-inertial guidance (AIG) in conjunction with a Convair "square canister" autopilot.

1. Sensing Platform - contained three accelerometers, two gyros, three pendulums and an alignment prism.

2. Digital Computer - integrated the accelerations and flight deviation sensed by the platform, and generated correction signals.

3. The final component of the MGS was a control central in which the necessary start, heat, alignment, and operation controls were housed.

R and D testing at AMR requires the use of two additional components for the airborne portion of the AIG equipment, a digital signal converter (DSC) and an analog signal converter (ASC).

The Convair autopilot package utilized in conjunction with D/AIG missiles differ from that used on previous "D" Series missiles in the following respects:

1. The canisters were rectangular in shape rather than round.

2. Switching in the programmer package was changed to electronic, rather than electro-mechanical.

3. The excitation transformer was removed from the filter servo-amplifier package and set in a separate housing.

Strobe Optical Beacon

Missile 60D was provisioned with a Strobe optical beacon system to provide additional tracking information after SECO. The system was housed in a single package mounted on the forward fairing of the B-1 pod (station 917.5). Internal components included the Strobe lamp, associated electronics, and a remotely activated primary battery. Battery activation was initiated during flight by the SECO command.

Upon receipt of the SECO command, the system also provided a 28V DC signal to a telemetry signal relay which switched telemetry channel "C" from a commutated mode to a continuous Strobe system source.

Each time the lamp flashed, a square wave pulse signal was provided to the telemetry system to furnish timing data.

Instrumentation System

Three telemetry links for missile system data. Two telemetry links for re-entry vehicle data.

Range Safety Command System

Range safety command system consisting of two ARW-62 receivers, (AVCO AD-319600 MK1), power and signal control unit, and destruct package.

Instrumentation and Range Safety System

GE Mod IIIE instrumentation beacon system in conjunction with the GE/Burroughs Mod III system. Standard AIG antennna configuration.

Asusa Transponder

Type B-1A coherent carrier transponder.

HISTORY OF XSM-65D MISSILE NO. 60

Atlas Missile 60D arrived at AMR by air transport (C-133) on 5 April 1960. Transfer to the R and D trailer and into temporary storage in the south bay of Hangar "K" was effected the same day. Temporary storage was necessitated by the fact that AIG checkout can only be accomplished in the north bay of Hangar "K" and Missile 54D was occupying that position at the time. Receiving inspection was completed on 8 April 1960 and tests which did not require the use of the checkout trailer were initiated.

Following the transfer of Missile 54D to Complex 11, Missile 60D was positioned in the north bay of Hangar "K" and the AIG checkout equipment was installed. Systems checkout was initiated on 18 May 1960.

Missile 60D remained at AMR for a period of approximately 13 weeks. The majority of this time was utilized in performing system tests and modifications and in readying the missile for flight test. However, approximately one month delay in testing was incurred due to the presence of Missile 54D in the AIG checkout bay.

Pre-flight testing of the missile was accomplished in accordance with planning documented in Report AA 60-0001, Flight Test Directive, Series "D", Missile No. 60. Unplanned operations were performed on an "as required" basis.

Significant events concerning Missile 60D from arrival at AMR to launch are listed chronologically below.

Date	Event
5 April 1960	Arrived at AMR by air and transferred to south bay of Hangar "K".
8 April 1960	Completed receiving inspection.
18 May 1960	Systems checkout initiated in north bay of Hangar "K".
13 June 1960	Weighed in Hangar "K".
14 June 1960	Transferred to Complex 11 and erected.

Date	Event
23 June 1960	Successful Propellant Tanking.
24 June 1960	Flight Acceptance Composite Test was performed and the following discrepancies were observed: 1. RF No. 1, Channel C, failed to switch to continuous for observation of Strobe light operation at sustainer cutoff. 2. Sustainer and vernier cutoff relay activations at generation of MFCO could not be ascertained because signal was sent at time when cutoff relays were already activated by ARMA cutoff signals. 3. Voltage and frequency shifts in the missile electrical and ARMA computer power supply measurements were evident at staging.
27 June 1960	Satisfactory Flight Acceptance Composite Test. Discrepancies were noted as follows: 1. Voltage and frequency shifts in the missile electrical and ARMA computer power supply measurements were evident at 170 seconds. 2. Malfunction of the Mod III instrumentation beacon was indicated at 375 seconds. Following this test the Mod III beacon and the missile inverter were replaced and checked satisfactorily.
29 June 1960	X-1 Day Operations.

Date	Event
30 June 1960	Attempted launch. The countdown started as planned at 1900 EST and was terminated at 2345 EST at -54 minutes. The test was terminated in order to allow time to change the RF No. 3 canister and the ASC after improper output was noted on ASC Channel 5.
2 July 1960	Flight.

Attempted Launch Countdown Results

The initial launch countdown occurred on 30 June 1960. The countdown was started as planned at 1900 EST and was terminated at -54 minutes. The test was terminated to allow sufficient time to change the RF No. 3 canister and the ASC and to further trouble shoot the problem area. Actual countdown time consumed totaled 285 minutes, 135 minutes of which were hold times. These holds were as follows:

1. At -139 minutes (1911 EST), for 34 minutes, to change telemetry RF No. 2 canister due to noise on this link.

2. At -70 minutes (2054 EST), for 28 minutes, to rerun the GAP test, which had been performed at -144 minutes, because of poor data checker functioning.

3. At -54 minutes (2138 EST), for 127 minutes, to resolve the improper frequency output as indicated by telemetry during the first run of the GAP test perfromed at -62 minutes. The test was terminated during this hold.

A brief compilation of significant difficulties encountered during system preparation and testing accomplished follows.

All-Inertial Guidance System

After installation of the Missile Guidance Set (MGS) components in the missile pod, the MGS system test was delayed approximately one week awaiting Convair wiring checks. Early in the system test, an electrical short was discovered in the 13,300 panel of the Alignment-Countdown Set (ACS) in Arma Checkout Trailer No. 1. Repairs were made and the system test was completed successfully except for delays caused by pod air conditioning and 400 cps power failures.

During the Guidance Integrated Test, the 21,300 panel of the ACS failed and was repaired without delaying the test.

The platform tumbled during an attempted FACT of 22 June due to a defective Missile Guidance Control. A new control (S/N 7120013) was installed. The Amplifier Fidelity Link was found to be saturated with water and was removed, dried out, and replaced. A low Digital Signal Converter output was traced to a defective power supply in the interconnection group of the ACS. The power supply was replaced, and on 24 June the FACT was completed successfully.

During the launch countdown of 30 June, the Data Checker failed during verification of the range tape from the first GAP Test. The Analog Signal Converter (ASC) exhibited a malfunction during the second GAP Test and the launch attempt was terminated. The Data Checker was repaired and a new ASC (S/N 7150016) was installed. On 1 and 2 July the launch countdown was completed successfully, with no Arma holds required.

The following test procedures were performed in the course of MGS checkout at AMR.

Procedure	Description	Date Completed
Hangar "N" Arma Maintenance Center		
CTO-80A	Platform Checkout	3-8-60
CTP-02	Partial Platform Checkout	4-4-60
CTP-03B	Computer DSC Checkout	3-9-60
CTP-03C	Computer DSC Checkout	5-5-60
CTP-15B	MGS System Test	5-9-60
CTP-12A	ASC Calibration	6-29-60

Procedure	Description	Date Completed
Hangar "K"		
DAG 6477	Trailer No. 1 ACS Validation	5-13-60
FTP-G-013D	MGS System Test (Partial)	5-19-60
FTP-G-013D	MGS System Test (Partial)	5-24-60
FTP-G-013D	MGS System Test	5-31-60
FTP-G-014D	Guidance Integrated Test	6-1-60
At Complex 11		
CTP-14A	Launch Pad ACS Calibration	6-17-60
CTP-15C	MGS System Test	6-18-60 6-21-60
CTP-17F	FACT No. 1 Precountdown	6-22-60
CTP-17F	FACT No. 2 Precountdown	6-24-60
CTP-17F	FACT No. 2 Countdown	6-24-60
Arma Test Spec. No. 37	Computer - Target Board Checks	6-21-60
CV-A Test Prep. No. 11-402	Control Checkout	6-23-60
CTP-17F	Partial FACT Countdown	6-27-60
CTP-15C	"X-2" Day Checks	6-29-60
CTP-15C	"X-1" Day Checks	6-29-60
CV-A Test Prep. No. 11-417	ASC Checkout	6-30-60

Procedure	Description	Date Completed
CTP-17F	Launch Attempt Precount	6-30-60
CTP-17F	Launch Attempt Countdown	6-30-60
CTP-17F	Launch Precountdown	7-1-60
CTP-17F	Launch Countdown	7-1-60

Re-entry Vehicle

The re-entry vehicle was received at AMR on 7 June 1960. No major problems arose during hangar testing. The following tests were performed at AMR.

FTI	Tests	Date Completed
23846A	Flare and Spacer	6-8-60
23847A	Systems Confidence	6-22-60
23893	Seal Test	6-22-60
23845D	Incoming Confidence	6-23-60
23885A	Mate Spacer to Airframe	6-24-60
23850C	FACT (Spacer only)	6-24-60
23885A	Remove Spacer from Airframe	6-24-60
23869A	Weight and C. G.	6-25-60
23848B	Final Acceptance	6-26-60
23885A	Mate to Airframe for Launch	6-29-60
23885A	T-1 Day	6-29-60

Flight Control System

During hangar checkout, gyro canister, Serial No. 8, was returned to San Diego, on 7 April 1960, due to low yaw displacement sensitivity and high pitch displacement sensitivity. Gyro canister, Serial No. 4, was assigned as a replacement.

During flight control system checkout at the complex, it was discovered that the flight programmer recycled intermittently for no apparent reason. Gyro canister, Serial No. 4, and programmer, Serial No. 3, were therefore replaced by gyro canister, Serial No. 13, and programmer, Serial No. 9. Programmer, Serial No. 3 was returned to San Diego. Subsequent checks in the gyro laboratory indicated that programmer, Serial No. 3, had an intermittent reset condition.

The following procedures were completed in the hangar checkout area.

Procedure	Description	Date Completed
FTP-S-047A	Autopilot Preliminary Voltage And Circuit Check	4-11-60
FTP-S-002A	Vernier Engine Alignment	5-19-60
FTP-S-041C	Autopilot System Test	5-19-60
FTP-S-044B	Position And Polarity Test	5-20-60
FTP-S-045A	Pyrotechnic Substitution Fuse Test	5-21-60
FTP-S-039A	Autopilot Static Gain Test	5-23-60

The following procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-S-006B	Booster Engine Alignment Check	6-16-60
FTP-S-021B	Flight Control System Threshold Transfer	6-16-60

Procedure	Description	Date Completed
FTP-S-034A	Sustainer Engine Alignment Check	6-16-60
FTP-S-049A	Autopilot Polarity Test	6-16-60
FTP-S-060A	Abbreviated Frequency Response Test	6-17-60
FTP-S-019C	Autopilot Frequency Response Test	6-17-60
FTP-M-062B	Autopilot Inertial Guidance Integrated	6-21-60
FTP-S-059	Roll Program Readout Calibration	6-28-60
FTP-S-050B	Autopilot Squib Test	6-29-60
FTP-S-051C	Autopilot System Readiness Test	6-29-60
FTP-S-052	Autopilot Precountdown Operation	6-30-60

Hydraulic System

The sustainer hydraulic system hydraulic oil did not meet specifications due to low viscosity when analysed prior to flight. The oil was approved as acceptable, however, since viscosity can be expected to drop when oil has been in use.

During preparations for launch, the vernier solo hydraulic line located in the thrust section jettison area broke when being reformed. The line was removed and replaced.

The following procedure was completed in the hangar checkout area.

Procedure	Description	Date Completed
FTP-H-005B	Horizontal Fill and Bleed	6-14-60

The following procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-H-002D	Ground And Airborne Hydraulic System Fill And Bleed	6-24-60
FTP-H-007	Vernier Solo Hydraulic Accumulator Installation	6-23-60
FTP-H-004	Airborne Hydraulic System X-1 Day And Precount Operations	6-30-60

Optical Beacon

During hangar checkout operations the optical beacon system was installed and checked out in accordance with TPS'S K-27 and J-92.

During the FAC Test optical beacon, Serial No. 004-0010, failed to activate and was replaced by optical beacon, Serial No. 003-0001.

The following procedure was completed at the complex.

Procedure	Description	Date Completed
FTP-E-049	Blockhouse Compatibility And Checkout Of Strobe Light Battery	6-15-60

Azusa System

During hangar checkout Azusa transponder, Serial No. 731-0044, was RT'd (IR No. 535612) and sent to the Azusa Field Service Center for testing after missile dc power had been inadvertently shorted to ground due to a faulty test equipment sandwich plug. Transponder, Serial No. 731-0046, was installed on the missile. Transponder, Serial No. 731-0044, was subsequently tested at the Field Service Center and was found to be undamaged.

The following procedure was completed in the hangar.

Procedure	Description	Date Completed
27-92504 EO "H"	Azusa Coherent Carrier Transponder System Checkout	5-17-60

The following procedure was completed at the complex:

Procedure	Description	Date Completed
FTP-Z-001A	Azusa Blockhouse Compatibility	6-15-60

Range Safety Command System

No major system difficulties were encountered during preparation for the flight test.

The following procedures were completed in the hangar.

Procedure	Description	Date Completed
27-92517-1-D EO "F"	Range Safety Command Checkout	5-18-60
FTP-D-002C	Range Safety Command Backup Re-entry Vehicle Separation Checkout	5-19-60

The following procedure was completed at the complex.

Procedure	Description	Date Completed
FTP-D-005B	Range Safety Command Blockhouse Compatibility Test	6-15-60

Acoustica Propellant Utilization System

No major difficulties were encountered during checkout in the hangar.

During checkout at the complex, Acoustica computer, Serial No. 043, was removed due to one station being out of specification. This unit was replaced with computer Serial No. 044, which performed satisfactorily.

The following procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-W-009	PLCM Calibration	6-16-60
FTP-W-008B	Acoustica Closed Loop System Calibration And Checkout	6-23-60
FTP-W-015	Acoustica Propellant Utilization System Specific Gravity Auto Set Voltage Adjustment	6-24-60
FTP-W-012	Acoustic PU System Function Readiness Test	6-28-60
FTP-W-019	PLCM Readiness Test	6-29-60

Pneumatic System

No major difficulties were encountered during checkout in the hangar.

During checkout at the complex, while performing FTP-F-020 (High Pressure Leak Check and Airborne Regulator Lock-Up Checkout), the fuel regulator experienced excessive leakage when pressurization was switched to internal. The regulator was subsequently replaced, and no further problems were encountered.

The following test procedures were completed in the hangar.

Procedure	Description	Date Completed
FTP-F-019B	Airborne Pneumatic System Leak Check	4-14-60
FTP-F-022B	Differential Pressure Switch Checkout	4-15-60
FTP-F-018A	PU System Leak Check	4-20-60

The following test procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-F-005C	Checkout and Validation Ground Airborne Pneumatic System	6-20-60
FTP-F-007	Transfer Missile Trailer Pressurization To Tower	6-21-60
FTP-F-020	High Pressure Leak Check and Airborne Regulator Lockup	6-22-60
FTP-F-015A	LO2 Tank Relief and Shutoff Valve Checkout	6-22-60

Holddown and Release System

No major difficulties were encountered during flight test preparation, however, several instrumentation problems were encountered during the cold release test.

The following procedures were completed after Missile 60D arrived at the complex.

Procedure	Description	Date Completed
FTP-L-001C	General Launcher Alignment	6-13-60
FTP-L-017A	Launcher Release System Functional And Restrictive Check	6-13-60
FTP-L-005B	Launcher Stabilization	6-16-60
FTP-L-007D	Functional Check Launcher Auxiliary Frame	6-16-60
FTP-L-008	Servicing Launcher Launcher Arrestors	6-20-60
FTP-L-0AA	Launcher Lines Leak Check	6-20-60
FTP-L-006B	Shakedown Procedure For Cold Release	6-27-60

Mod IIIE Instrumentation Beacon System

During hangar checkout, while performing test procedure FTP-G-020A (Mod IIIE Instrumentation Beacon System Checkout Procedure), no voltage proportional to rate beacon r-f power output was observed. Rate Beacon, Serial No. 4E1046, was removed from the missile (F and C No. 531109) and sent to the GE Lab. Testing verified the aforementioned condition and the rate beacon was returned to the depot for repair. Rate Beacon, Serial No. 4E1074, was installed on the missile.

During checkout at the complex, while performing test procedure FTP-G-016A (Mod IIIE Instrumentation Beacon System Readiness Test), a low voltage proportional to pulse beacon magnetron current was observed. Pulse Beacon, Serial No. 6E 1006, was removed from the missile and sent to the GE Lab. Testing indicated normal pulse beacon performance and the pulse beacon was re-installed on the missile. The aforementioned problem was still present during subsequent testing and Pulse Beacon, Serial No. 6E1006, was removed from the missile and Pulse Beacon, Serial No. 6E1004, was installed. The problem still persisted and further investigation revealed that this condition was caused by trouble in the Mod IIIE test set acceleration register.

During the plus time count on the Flight Acceptance Composite Test (P1-4CO-02-60) on 27 June 1960, it appeared that the pulse beacon power supplies had been damaged due to improper application of missile electrical power. Pulse Beacon, Serial No. 6E10004, and Rate Beacon, Serial No. 4E1074, were removed from the missile and sent to the GE Lab. the lab check confirmed that the pulse beacon power supplies had been damaged and the Pulse Beacon, Serial No. 6E1005, was assigned as the replacement. A lab profile test was satisfactorily completed and Pulse Beacon, Serial No. 6E1005, and Rate Beacon, Serial No. 4E1074, were installed on the missile.

The following procedures were completed in the hangar.

Procedure	Description	Date Completed
FTP-G-020A	Mod IIIE Instrumentation Beacon System Checkout	5-25-60 DA 1043
TPII-K-89	Instrumentation Rate and Pulse Beacon Removal for GE Lab Test	6-7-60

The following procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-G-016A	Mod IIIE Instrumentation Beacon System Readiness Test	6-22-60 6-29-60
FTP-G-019A	Mod IIIE Instrumentation Missileborne Waveguide and Canister Pressure Check	6-29-60

Missile/Complex Electrical

During FAC Tests P1-4CO-01-60 and P1-4CO-02-60, the missile main inverter indicated a small voltage and frequency shift once in each test. This shift was also present on the ARMA guidance computer power supply measurements. Missile inverter, Serial No. 905-0014, was removed and replaced by inverter, Serial No. R88, to remove the electrical system as a possible source of trouble. No further shifts were noted.

During the launch countdown the remotely activated missile main battery failed to activate. The battery, Serial No. 906-0227, was removed and replaced with battery, Serial No. 001-0465.

The following procedures were completed in the hangar.

Procedure	Description	Date Completed
FTP-E-033	Inspection of Electrical Disconnects	4-6-60
FTP-E-044	Battery Fit Test	4-19-60
FTP-E-036	Separation Circuitry Check	4-6-60
27-92518-A EO "C"	Missile Electrical System Checkout	6-2-60

The following procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-E-003	Operational Checkout of Closed Circuitry.	6-17-60
FTP-E-026	Pneumatic/Propulsion/ Electrical System Interlock Test.	6-21-60
FTP-E-032B	Missile Electrical Blockhouse Compatibility Test.	6-20-60
FTP-B-013A	Propellants and Explosive Area Checkout and Trial Fitting of Pyrotechnic Devices.	6-28-60
FTF-M-056B	Missile RF and Electrical Readiness Test.	6-29-60
FTP-M-0 64A	Missile RF and Electrical Pre-Count Operations.	7-1-60

The complex electrical encountered the following difficulties during the checkout and launch of this missile.

1. Umbilical 600J3 was discovered to be a flush mounted type. Procedure FTP-E-037B, had to be deviated (DA1061) to allow proper adjustment of 600P3.

2. Umbilical 600P2, had an open circuit between 600P2-10 and 600P109-H. The circuit was repaired.

3. The ARMA line of sight tube harness was wired to B/P 27-69938 configuration.

4. The 480 volt wiring for the pod cooling strip heaters was shorted to the conduit. Repairs were postponed until after launch. This did not hamper the complex operation.

5. Umbilical 600P3 was found to be contaminated causing the vernier propellant valves to open and the vernier start tanks to pressurise several times intermittently during leak checks. This was corrected by blowing out the umbilical with GN2.

The following procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-E-034	Launch Microswitch Adjustment	6-14-60
FTP-E-037	Umbilical Adjustment Ejection Procedure	6-20-60 DA 1061
FTP-E-038B	Complex Electrical System Readiness Test	6-29-60
FTP-E-039	Launch Control Automatic Sequence Test	6-21-60
FTP-E-040	Release Sequence Test	6-20-60 DA 1065
FTP-E-041	Sustainer Overspeed Trip Check	6-15-60
FTP-E-046	Checkout Hydraulic Switch	6-24-60

Propulsion System

Removal of two high pressure lines from the booster LO2 system and the sustainer and booster gas generator LO2 feed lines for hydrocarbon count revealed that the LO2 system lines were out of specification in particle size and count. This brought about an inspection and cleaning of the remaining high and low pressure lines in the booster main LO2 system from the RMI (staging) valve down.

During Vernier Engine leak checks, after the engine tanks were pressurized, the vernier propellant valves inadvertently opened. The propellant valves could not be closed nor could the engine tanks be vented by use of the engine test panel. After the panel switch had been put into the vent position the tanks vented and repressurized twice. The engines were returned to a normal configuration by disconnecting the plugs controlling the engine tank pressure and vernier propellant valves. Further investigation revealed an appreciable amount of water in umbilical 600P-3. The umbilical was dried out and a voltage check on the plugs to the propellant valve control and engine tanks pressurizing control solenoids before and after drying out confirmed that the extraneous signals were removed. Due to opening of the propellant valves the vernier LO2 lines downstream of the propellant valves were removed for contamination checks. All the lines were cleaned and the gimbal joints on V2 were flushed with alcohol and purged.

The interference between the vernier engine flexible electrical conduit and the LO2 lines was experienced again on both engines. This was corrected by hand fitting the clamp spacers.

The following procedures were accomplished in the hangar.

Procedure	Description	Date Completed
FTP-P-027	Main Propellant and Hot Gas System Leak Checks	4-15-60
FTP-P-025	Propulsion Pneumatic Control Leak and Functional Check	5-20-60
FTP-P-026	Vernier Engine and Start System Leak Checks	5-26-60
FTP-P-030B	Head-Suppression Servo Controller Leak and Functional Check	6-2-60

The following procedures were accomplished at the complex.

Procedure	Description	Date Completed
FTP-P-013	Airborne Purge and Pre-valve Leak and Functional Test	6-17-60
FTP-P-029	Pneumatic Purge System Leak And Functional Check	6-16-60
FTP-P-023	Inspection Check of Propulsion System Components	6-24-60
FTP-P-017	Vernier Engine Decontamination	6-25-60
FTP-P-006	Propulsion System Leak And Functional Check	6-27-60
FTP-P-014	Retorquing Booster and Sustainer Gimbals	6-28-60
FTP-P-009	Propulsion X-1 Day and Pre-Countdown Operation	6-30-60

Telemetry System

During the launch attempt on 30 June 1960, (Test P1-401-00-60) Telemetry RF No. 2 canister, Serial No. 9619, became noisy and was removed from the missile. Canister, Serial No. 944, was installed.

During the launch precount on 1 July 1960, Telemetry RF No. 3 canister, Serial No. 9611, was removed from the missile after it was suspected that the signal was not being transmitted properly. Canister Serial No. 958, was installed.

The following procedures were completed in the hangar.

Procedure	Description	Date Completed
FTP-T-005	Bridging of Temperature Transducer and Accessory Package Resistance	6-28-60
FTP-T-017	Vernier Engine Position Calibration	5-17-60
FTP-T-024A	Telemetry System Checkout Procedure	5-19-60
FTP-T-023	Telemetry High Pressure Checkout	5-23-60
FTP-T-022	Telemetry System Functional Check	6-2-60
TPS-K-81	Accessory Output Check	6-1-60

The following procedures were completed at the complex.

Procedure	Description	Date Completed
FTP-T-020A	Telemetry System Functional Test	6-17-60
FTP-T-019B	Telemetry Blockhouse Compatibility Test	6-21-60
FTP-T-008B	Alignment and Calibration of Engine Position Transducers	6-23-60

Procedure	Description	Date Completed
FTP-T-026	Telemetry System Readiness Test	6-30-60
FTP-T-027	Telemetry System Precount-down Operations	7-1-60

APPENDIX

FLUID CHEMICAL ANALYSIS

All Fluid Chemistry samples were taken for Missile 60D launch on 1 July 1960. The results were acceptable. The trichloroethylene sample was insufficient to allow complete analysis but was within specifications as far as tests were performed.

Liquid Oxygen	Units	Sample	Specifications
Purity	Percent	99.65	99.5 Min.
Hydrocarbons			
As Methane	ppm	10	75.0 Total Max.
As Acetylene		None	0.5
Gaseous Nitrogen			
Purity	Percent	99.9	99.5 Min.
Hydrocarbons			
As Methane	ppm	None	75.0 Total Max.
As Acetylene		None	0.5
Gaseous Helium			
Purity	Percent	99.99	99.9 / Min.
Hydrocarbons			
As Methane	ppm	None	75.0 Total Max.
As Acetylene		None	0.5
Lubricating Oil			
Viscosity	Centistokes @ 100°F	25	23-34
Flash Point	°F	310	280 Min.
Viscosity Index	136.7	134.8	80 Min.

Fuel - RP-1	Units	Sample	Specifications
Initial Boiling	°F	372	Report
10 Percent	°F	392	365-410
50 Percent	°F	417	Report
90 Percent	°F	450	Report
End Point	°F	474	525 Max.
Residue	Percent	0.8	1.5 Max.
Loss	Percent	1.0	1.5 Max.
Flash Point	°F	138	110 Min.
Gravity	°API	44.0	42.0 Min.
Particle Count			
10 - 20	Microns	2460	No solid particles greater than 175 microns. (Fibers not defined).
20 - 40	Microns	840	
40 - 80	Microns	60	
80 +	Microns	5 Particles 5 Fibers	
Moisture Content	ppm	None	5.0 Max.

Trichloroethylene

Appearance		Pass	Clear and Free.
Color		Pass	Not Red, Blue, Green, or Purple Dyed.
Odor		Pass	Characteristic.
Water Content		Pass	Cloudless @+14°F

Insufficient sample to complete testing. Material is within specification as far as tests were performed.

Hydraulic Fluid

Flash Point	°F	215	200 Min.
Color		Red	Report
Viscosity	Centistokes @ 130°F	8.9*	10.0 Min.
Water by Distillation	Percent	Cannot be measured by spec. method.	0.005 Max.
Dye		Red	

Particle Count	Units	Sample	Specifications
10 - 20	Microns	1320	4800 Max.
21 - 40	Microns	840	2400 Max.
41 - 65	Microns	50	800 Max.
66 - 100	Microns	40	160 Max.
Over 100	Microns	2 Fibers 3 Particles	0 Max.

* Below procurement specifications, however, viscosity can be expected to drop after oil has been in use and this value is acceptable.

REFERENCE DOCUMENTS

Flight Test Plan - Missile No. 60D	AZ-27-091
Detailed Test Objectives(AFBMD/STL)	TR-60-0000-09059
Flight Test Directive (FTWG)	AA 60-0001

Additional reports which may be referenced for further information regarding this missile are listed below:

Reports	Approximate Issue Date (time after test)
Convair - Astronautics, San Diego, Calif.	
Flight Test Evaluation Report	14 Days
AFBMD/STL, Inglewood, Calif.	
Flight Summary Report	8-12 Weeks
ARMA, CCO	
CCO Quick Look Report	7-10 Days
American Bosch ARMA Co., Garden City, N. Y.	
Flight Test Evaluation Report	30 Days
General Electric, Philadelphia, Pa.	
Evaluation Report	30 Days
General Electric, Syracuse, N. Y.	
Evaluation Report Of Mod III Instrumentation System With Missile 60D.	6-10 Weeks
Acoustica Associates, Los Angeles, Calif.	
Final Test Report	30 Days

SERIAL NUMBERS OF SYSTEM COMPONENTS

AZUSA TRANSPONDER, Serial No. 731-0046

RE-ENTRY VEHICLE, Serial No. 223

RANGE SAFETY COMMAND SYSTEM

Range Safety Command Receiver No. 1, Serial No. AF-58-125
Range Safety Command Receiver No. 1, Batter, Serial No. 909-0018
Range Safety Command Receiver No. 2, Serial No. AF-58-164
Range Safety Command Receiver No. 2, Battery Serial No. 238
Range Safety Command Power And Signal Control Unit, Serial No. 5

PROPULSION SYSTEM

Sustainer Engine, Serial No. NA 222079
Booster Engine, Serial No. NA 112095
Vernier No. 1, Serial No. NA 332185
Vernier No. 2, Serial No. NA 332099

ELECTRICAL SYSTEM

Missile Main Battery, Serial No. 001-0463
Inverter, Serial No. R-88
Power Changeover Switch, Serial No. 010

INSTRUMENTATION BEACON SYSTEM

Pulse Beacon, Serial No. 6E1005
Rate Beacon, Serial No. 4E1074

TELEMETRY SYSTEM

Telemeter RF No. 1, Serial No. 9612
Telemeter RF No. 2, Serial No. 944
Telemeter RF No. 3, Serial No. 958
Telemeter RF No. 1, Battery, Serial No. 001-0120
Telemeter RF No. 2, Battery, Serial No. 002-0190
Telemeter RF No. 3, Battery, Serial No. 001-0126
Accessory Package, Serial No. 005-0005 (12)

FLIGHT CONTROL SYSTEM

Gyro Package, Serial No. 003-0004 (13)
Filter-Servo Amplifier Package, No. 002-0003 (10)
Programmer Package, Serial No. 001-0001 (9)

PROPELLANT UTILIZATION SYSTEM

Canister, Serial No. 044

INERTIAL GUIDANCE SYSTEM

Platform, Serial No. 7110014
Control, Serial No. 7120013
Computer, Serial No. 7130018
Analog Signal Converter, Serial No. 7150016
Digital Signal Converter, Serial No. 7140029

STROBE LIGHT SYSTEM, Serial No. 003-0001

SIGNIFICANT DATES DURING TESTING OF "A" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
4A	12-8-56	14	3-22-57	6-3-57	6-11-57	895	Engine shut down at 29.9 seconds of flight. Missile destroyed at 50.1 seconds.
6A	4-4-57	14	8-2-57	9-20-57	9-25-57	1422	Engine shut down at 47.7 seconds of flight. Missile destroyed at 74 seconds.
12A	11-1-57	14	11-20-57	12-11-57	12-17-57	2148	Successful flight. Impacted approximately 490 nm downrange.
10A	7-18-57	12	9-27-57 10-27-57 11-6-57	*11-27-57 **12-10-57 1-4-58	1-10-58	10	Successful flight. Impacted approximately 542 nm downrange.
13A	12-4-57	14	1-17-58	***1-31-58	2-7-58	222	Engine shut down prematurely at 117.8 seconds of flight due to flight control system failure. Missile broke up at 167 seconds.
11A	12-28-57	12	1-25-58	2-8-58	2-20-58	449	Engine shut down prematurely at 124 seconds of flight due to flight control system failure. Missile broke up at 126.5 seconds.
15A	1-6-58	14	2-26-58	3-22-58	4-5-58	634	Engine shut down prematurely at 105 seconds of flight due to B1 turbopump failure. Missile remained intact and impacted approximately 200 miles downrange.
16A	2-5-58	12	3-17-58	****4-18-58 5-22-58	6-3-58	1261	Successful flight. Impacted approximately 480 nm downrange.

* Premature cutoff at 8 seconds. Both booster chambers damaged, necessitating replacement.

** Full duration, but damaged B1 chamber, necessitating replacement.

*** FRF terminated prematurely, but considered satisfactory.

**** Prematurely terminated due to APS shutdown.

SIGNIFICANT DATES DURING TESTING OF "B" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
3B	4-22-58	11	5-29-58	*6-23-58 **6-27-58 7-8-58	***7-12-58 7-19-58	1564	Missile broke up at 42 seconds of flight. Due to failure of the yaw rate gyro.
4B	5-31-58	13	6-13-58	7-15-58	8-2-58	1382	Successful flight. Impacted approximately 2345 nm downrange.
5B	5-30-58	11	7-22-58	8-20-58	8-28-58	1383	Successful flight. Impacted approximately 2853 nm downrange. First completely closed loop guidance system flight.
8B	7-31-58	14	8-4-58	9-4-58	9-14-58	1511	Successful flight. Impacted approximately 3151 nm downrange.
6B	7-17-58	13	8-14-58	9-10-58	9-18-58	1512	B1 turbopump failed at 80.8 seconds after lift-off. Missile exploded two seconds later.
9B	8-7-58	11	9-12-58 ##9-30-58	#10-4-58 ##10-24-58 ###10-27-58	11-17-58	1513	Depletion of fuel supply caused simultaneous premature sustainer and vernier shutdown. Missile impacted 800 to 900 nm short of intended impact point. First flight of modified booster turbopumps.
12B	9-4-58	14	11-8-58	11-24-58	11-28-58	1730	Successful flight. Impacted approximately 5506 nm downrange.
10B	10-22-58	11	11-[illegible]-58	****12-9-58 ***12-10-58 12-12-58	12-18-58	1729	Successful flight. Missile placed into orbit.
13B	12-4-58	14	12-5-58	12-22-58	1-15-59	30	Flight prematurely terminated due to unexplained difficulties starting at 100 seconds after liftoff. Missile impacted 120 nm downrange. There was no telemetry system aboard this missile.
11B	8-22-58	11	12-23-58	1-20-59	2-4-59	29	Successful flight. Impacted approximately 3122 nm downrange.

* Automatic cutoff initiated by sustainer overspeed/underspeed trip 1.96 seconds after BOG links break.

** Automatic cutoff initiated by sustainer overspeed/underspeed trip 1.08 seconds after BOG links break.

*** Prematurely terminated by an automatic cutoff 4.98 seconds after BOG links break.

**** Vernier ignition only.

\# Manual cutoff at 6.69 seconds.

\## After installation of "C" Series power pack in Hangar "J".

\### Automatic cutoff initiated by sustainer overspeed/underspeed trip 1.0 seconds after BOG links break.

\#### Full duration, but engine compartment fire delayed schedule approximately 10 days.

SIGNIFICANT DATES DURING TESTING OF "C" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
3C	10-31-58	12	11-4-58 *11-25-58	12-17-58	12-23-58	2501	Successful flight. Impacted approximately 3803 nm downrange.
4C	11-9-58	12	1-6-59	1-19-59	1-27-59	10	Although impact was close to intended point, the guidance system did not function.
5C	1-31-59	12	2-4-59	None	2-20-59	251	Missile exploded at 174 seconds due to a malfunction at staging. Probable cause was improper operation of the fuel staging valve.
7C	2-12-59	12	2-23-59	None	3-18-59	761	Booster engine shut down prematurely at 131 seconds of flight. Missile was unstable for remainder of flight.
8C	5-7-59	12	5-11-59	**5-22-59 **7-9-59	#7-15-59 7-21-59	2103	Successful flight. Impacted in target area 4385 nm downrange. RVX-2 Re-entry Vehicle recovered.
11C	7-15-59	12	7-25-59	8-'4-59	8-24-59	2121	Successful flight. Impacted almost 5 miles long in MILS net due to residual thrust after vernier cutoff. Re-entry Vehicle was recovered.
9C	4-4-59	12	4-15-59 ##8-17-59	***9-24-59		2944	

* After power pack modification.

** Two successful Flight Readiness Firings performed.

*** Destroyed by fire and explosion following premature cutoff.

\# Ignition achieved twice. Manual cutoff for 1st. attempt in vernier ignition phase. Second attempt terminated by release timer.

\## Erected twice due to cancellation of test and subsequent return to hangar for storage.

SIGNIFICANT DATES DURING TESTING OF "D" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
3D	2-25-59	13	2-27-59	3-27-59	4-14-59	1002	Booster section exploded 27 second - after liftoff due to failure to close airborne LO2 fill and drain valve. Missile destroyed at 37 seconds.
7D	3-20-59	14	4-13-59	5-8-59	*5-15-59 5-18-59	1754	Missile exploded at 65 seconds due to improper launcher operation which resulted in loss of fuel tank pressure.
5D	3-8-59	13	4-28-59	5-15-59	6-6-59	1753	Missile exploded at 160 seconds due to a malfunction at staging. Probable cause was improper operation of the fuel staging valve.
11D	4-10-59	11	5-11-59	**7-14-59 7-22-59	7-28-59	2002	Successful flight. Impacted 4384 nm downrange less than 1/2 mile from target in MILS net.
14D	5-7-59	13	6-10-59	7-28-59	8-11-59	2003	Successful flight. Impacted in MILS net less than 1 mile from target.
10D	4-10-59	14	6-2-59 ***7-22-59	9-3-59	9-9-59	2119	Successful flight although booster section failed to jettison. Project Mercury Capsule recovered.
17D	5-27-59	13	8-17-59	9-9-59	9-16-59	2106	Successful flight. Impacted 2 miles short of target in MILS net due to failure of vernier solo hydraulic package.
18D	5-27-59	11	9-2-59	None	10-6-59	2120	Successful flight. Impacted in MILS net less than 1/2 mile from target.
22D	8-26-59	13	9-21-59	None	10-9-59	3505	Successful flight. Impacted in MILS net less than 1 1/2 miles from target.
26D	9-18-59	11	10-8-59	None	10-29-59	2344	Due to malfunction of V2 engine at staging, impacted approximately 14 miles short of target point.
28D	9-18-59	13	10-14-59	None	11-4-59	4203	Unsuccessful. A/B IP failure prevented Station 5 IP system from acquiring the missile. Range safety cutoff caused R/V to impact approximately 260 miles short of target.
15D	5-9-59	11 14 13	7-11-59 9-23-59 11-7-59	None	11-24-59	2105	Successful although re-entry vehicle did not separate. Impacted in MILS net.

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SIGNIFICANT DATES DURING TESTING OF "D" SERIES FLIGHT MISSILES AT AMR (Cont'd)

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
20D	9-10-59	14	10-19-59	None	11-26-59	4122	Atlas/Able IV lunar probe. Atlas portion of flight was successful. Portions of Able failed at 47 sec.
31D	10-10-59	13	11-28-59	None	12-8-59	3286	Successful flight. Impacted 1/2 mile from target in MILS net.
40D	11-20-59	13	12-10-59	None	12-18-59	16	Successful flight. Delivered a Mk-2 Re-entry Vehicle within 3 nm of target point over a 5500 nm range.
43D	12-8-59	13	12-22-59	None	1-6-60	32	Successful flight. Delivered a Mk-3 Re-entry Vehicle within 3 miles of target point over a 5500 nm range.
44D	12-17-60	13	1-11-60	None	1-26-60	54	Successful flight. RVX4-A2 Re-entry Vehicle impacted approximately 1/2 mile from target in MILS net.
49D	1-6-60	13	1-28-60	None	2-11-60	320	Successful flight. Mk-3 Re-entry Vehicle impacted less than 1 1/2 nm from target over a 5500 nm range.
29D	10-10-59	14	1-18-60	None	2-26-60	304	MIDAS I Booster shot. Atlas portion of flight was successful.
42D	12-8-59	11	12-21-59	#2-4-60 2-23-60	#3-4-60 3-8-60	17	Successful flight. First missile to use all-inertial guidance system open loop.
51D	1-29-60	13	2-15-60	None	3-10-60	775	Destroyed by fire and explosion immediately after liftoff.
47D	2-19-60	11	3-10-60	None	4-7-60	361	Destroyed in the stand by fire and explosion during a launch attempt.
56D	3-3-60	12	4-11-60	None	#5-12-60 5-20-60	1865	Successful flight. Delivered Mk-3 Re-entry Vehicle within 4 nm of target point over an extended range of 7859 nm.
45D	1-26-60	14	3-2-60	None	5-24-60	619	MIDAS II Booster shot. Atlas portion of flight completely successful.
54D	2-25-60	11	5-13-60	None	6-11-60	615	Successful flight. Delivered Mk-3 Re-entry Vehicle 4306 nm downrange within 2.2 nm of target. First flight with AIG system providing active guidance functions.

SIGNIFICANT DATES DURING TESTING OF "D" SERIES FLIGHT MISSILES AT AMR (Cont'd)

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
62D	4-19-60	14	5-26-60	None	6-22-60	801	Impacted approximately 18 nm long due to failure of the vernier engines to shut-down when the guidance cutoff discrete was received.
27D	5-27-60	12	6-4-60	None	6-27-60	1002	Successful flight. Impacted within 1 nm of target in MILS net 4388 nm downrange.

* Launch aborted due to faulty release timer which initiated automatic cutoff.

** Test terminated by sustainer rough combustion cutoff circuitry.

*** Returned to hangar for booster power package replacement.

\# Recon due to Guidance System difficulties.

\#\# Engine cutoff prior to release due to erroneous callout in blockhouse.

\#\#\# Terminated by erroneous output from B2 primary RCC accelerometer.